VOL·IX NO·6

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

·S·A·E

DECEMBER 1921

STANDARDIZATION NUMBER

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. IX December, 1921 No. 6

The Foremost Economic Force in the Automobile Industry

THE accruing benefits in dollars and cents of the 300 established Standards and Recommended Practices of the Society of Automotive Engineers are astonishing in amount. In view of the inestimable prospective value to be attributed to them, and in appreciation of the responsibility resting on the Society at this time of economic pressure, this issue of THE JOURNAL is devoted largely to the purpose of bringing home the necessity for intelligent study and support of standardization as a prime eradicator of waste effort and expense.

A predominating number of the members of the Society have understood for years the basic necessity of automotive engineering standardization. There has been, however, some lack of comprehension of the extent and magnitude of the money-saving effected by it and of the clear need for extending the work in scope and intensity.

The actual work of the American Automobile Standards movement was started by the engineering section of the industry. Only the engineers could initiate such work in a concrete constructive way, and their continued support, based on strong conviction, was essential to the success of the plan. It is obvious, as it has been all along, that the full force and advantage of attainable simplification and economy in the methods of design, production and use of automotive apparatus are not securable without the whole-hearted attention and cooperation of the executives of the industry.

The work has now reached a stage where a unified movement all along the line, in which the National Automobile Chamber of Commerce and the Motor & Accessory Manufacturers' Association will take a more active part than heretofore, is in prospect. All sound work must be based upon proper test over a sufficiently long period. Pioneering is a thing apart and its fruits must stand on their merits for inevitable though delayed recognition. The success that has been attained by S.A.E. Standardization would have been impossible without constant and ever-increasing cooperation of a remarkably loyal nature from the industry in general. These facts, as well as many other salient features of the work, are made plain by statements of well qualified men in this special issue of THE JOURNAL.

Discussion of the industrial conditions and needs involved is in order at this time of the issuance of the 16 Standards Committee Division Reports that are to be considered on Jan. 10 at the Engineering Societies Building, New York City. Every keen student of the industry should scan these closely.

EXECUTIVES' AID ESSENTIAL

The procedure of the Society is based on the patent fact that the engineers alone cannot, even by extraordinary effort, bring about adequate and widespread standardization in actual practice, for the simple reason that the concurrent willing and hearty support of the executives of the industry is requisite. This applies not only to the use of present S.A.E. Standards but to a still greater degree to obtaining a further measure of standardization in every practicable direction. The full benefits of standardization cannot be had in the face of executive opposition. Neither can they be had from the listless acquiescence of any important section of the industry. The matter is primally one of all pulling together. The stake is a big one.

The profits from standardization begin with the

first operation of fabrication of material or part, and increase in amount through the various stages of trade and commerce, until the user of automotive apparatus is reached. He reaps the greatest benefit of all. Resistances of all kinds to the sale, operation and maintenance of motor vehicles must be eliminated or greatly reduced. There is nothing more effective in this connection than rational engineering standardization. Its invariable effect is to enhance quality and decrease cost of product. *Service,* long discussed in many quarters, is yet a largely unsolved problem. Basically, nothing is as necessary to motor-vehicle maintenance as systematic service conducted promptly at costs fair to all concerned. The satisfactory solution of this problem can be greatly hastened by more complete standardization. The greater the use of automotive apparatus, the greater the need for standardization.

Saving in Dollars and Cents

The assignment of a definite value to the saving effected by the use of S.A.E. Standards in the automotive industry is difficult. An analysis of estimates made by 146 engineers and executives of leading companies in the automotive field indicates their opinion to be that this saving amounts to 15 per cent of the total annual retail value of automotive products. If current estimates of $5,000,000,000 be accepted as correct for this annual production value, it will be seen that the saving would amount to $750,000,000. While this figure is staggering and may be disputed, it nevertheless should act as a stimulus for the individual to determine whether full realization from the value of S.A.E. Standards is being obtained by his company.

The saving specified indicates what has been accomplished through the partial adoption in practice of the 300 standards established by the Society. A brief comparison of these standards with the parts and materials that might be standardized will indicate the astounding possible saving ahead. This saving will be realized, however, only at the direction of the company executives. The application of a standard to a design may require a large amount of thought and time on the part of the engineer. It may be easier for him to not incorporate the standard. There may be no immediate return or saving that could be credited to the engineering department. The executives of the company, having primarily the responsibility for the welfare of the company as a whole, can evaluate the cumulative saving in dollars and cents possible during approaching years from the general adoption of standards, and should direct the efforts of the engineering, production and sales departments to this end. This statement is in no sense invidious to the engineer. He has created and will support the standards. It is an economic fact that where the authority is, there responsibility lies. Both are with the executive in last analysis. This is no time to ignore economic facts.

Nature of Standardization

Standardization is the codification of the best current common practice in the specification of materials and certain characteristics of design. It cannot be said that standardization has impeded the progress of automobile design. It has without question been a great aid to its progress. In addition, without S.A.E. Standardization the sales prices of new and used cars could never have been as low as they have been. The same statement applies to all other automotive apparatus. The standards consist of material, design and mounting-dimension specifications for those things that are essential in the present types of vehicle.

As a case in point, the S.A.E. Steel Specifications, established over 15 years ago, since supplemented annually and just now completely revised, constitute one of the greatest achievements of any industry. Their effect has been to reduce the price of steel by a large percentage. These standards eliminated a great many former specifications that were nearly identical, and enabled the steel-maker to develop a business of great magnitude in a relatively few compositions, whereas before he had been trying ineffectually to satisfy too many varying demands. The unguided whim of the designer no longer ruled, and it became possible for the steel producer to carry materials in stock and meet without delay the requisitions of the automotive trade. The use of high-priced branded steel decreased greatly. Much light was thrown on the subject of alloy-steels, this resulting in markedly increased utilization of them, as well as lower prices by reason of the greater volumes and fewer kinds. The automotive manufacturer could purchase S.A.E. Standard material on the open market, instead of having on his hands a large number of special undertakings necessitating the threshing out of many details with each of several producers. He escaped excessive cost by avoiding special fabrication of materials or the special machining of parts, and accomplished a 50-per cent or greater saving in the purchase of relatively small lots. The cost of standardized gages, to mention another example, became less than one-third of that of similar gages made to special requirements. The S.A.E. Screw Standard not only provided a much needed article, but, like many other Society standards, has had a very decided educational effect upon designers and producers. To do the same work it required less material, thereby reducing material cost, as well as the weight, of automotive apparatus considerably.

It must be borne in mind that the automobile business, inaugurated less than a generation ago, introduced almost innumerable engineering, manufac-

turing and industrial problems which demanded and still demand prompt and skilful attention. Engineering is the science of producing with the minimum of waste effort. The Society of Automotive Engineers has been all along a working agency of high efficiency in these circumstances. Useless duplication of sizes of stock parts and unnecessary divergence in specification and design have been eliminated to a large degree. Today, the fact that a manufacturer may be able to produce according to non-standard specifications a very large number of parts at as low cost as he could produce them according to standard specifications, does not obviate the necessity for standardization, because national, not to speak of world-wide, service demands more than the expedient procedure of any one company.

Industrial Solidarity

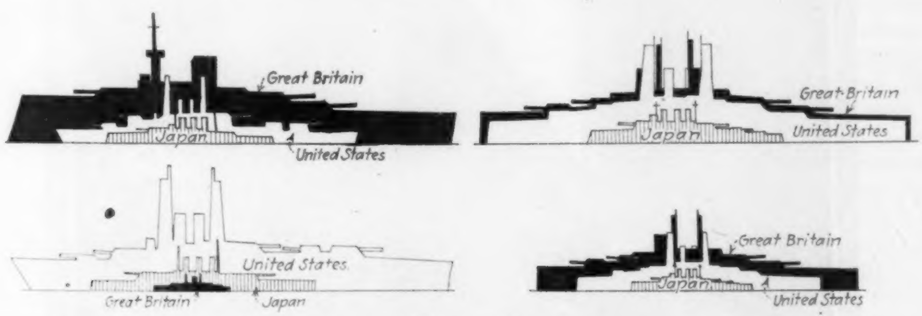
The Society has conducted consistently for many years a headquarters at which the interests of the designer, the buyer, the manufacturer and the motor-car purchaser, invariably discrepant and frequently antagonistic, have been frankly and conclusively discussed and acted upon for the general good. This has contributed greatly to the solidarity and the advancement of the whole automotive industry. It has provided a clearing-house for every pertinent phase of engineering. Such methods result in a rounding-out that makes each individual engineer taking part in the work, no matter how brilliant he may be, more capable than he otherwise would have been. The possibilities of success of any one company are linked indissolubly with the reputation and the prosperity of the whole national industry of which it is a part. There is trade advantage to any company in participating in the establishment and practice of intelligent standardization. Standardization is an economic benefit to any design. It represents always the best proven practice in the art.

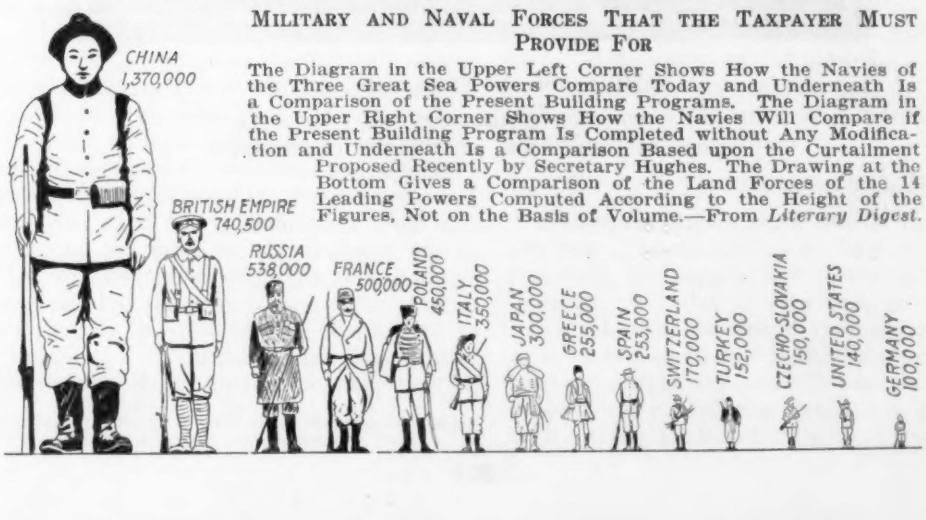
Conclusion

The automotive industry is extending its sphere of influence throughout the world. It is laboring strenuously to foster and coordinate as much as possible those phases of automotive production that are so essential to industry and human welfare. In international trade, it is obvious that the need of the maintenance of standardization will make possible the interchangeability of numberless materials, parts and accessories, is inexorable.

The Society has grown from small beginnings to full stature and maturity. The automotive industry and the public may well be grateful to its founders and to the many splendid men who have served them devotedly and with conspicuous success for over a decade. They have furthered the development of motor-vehicle transportation. They have trained the younger men. They have promulgated economies and modern principles in the fields of automotive manufacture and maintenance. Thus, for its record of practical achievement the Society of Automotive Engineers is unique.

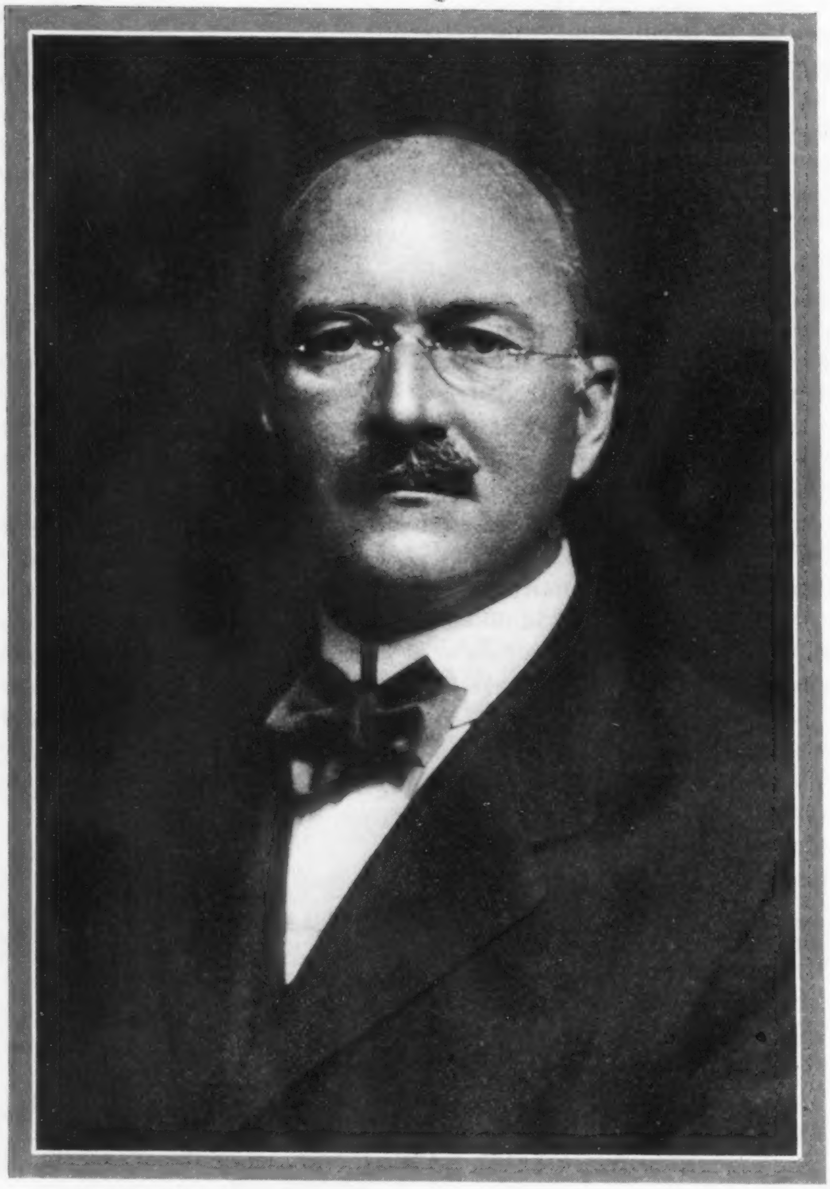
Standardization is the foremost economic force in industry. The words of Secretary Hughes on disarmament apply to it at this time: *What was convenient or highly desirable before is now a matter of vital necessity.*





Military and Naval Forces That the Taxpayer Must Provide For

The Diagram in the Upper Left Corner Shows How the Navies of the Three Great Sea Powers Compare Today and Underneath Is a Comparison of the Present Building Programs. The Diagram in the Upper Right Corner Shows How the Navies Will Compare if the Present Building Program Is Completed without Any Modification and Underneath Is a Comparison Based upon the Curtailment Proposed Recently by Secretary Hughes. The Drawing at the Bottom Gives a Comparison of the Land Forces of the 14 Leading Powers Computed According to the Height of the Figures, Not on the Basis of Volume.—From *Literary Digest.*



A PIONEER IN STANDARDIZATION

THE LAMENTED HENRY SOUTHER, FIRST CHAIRMAN OF THE S.A.E. STANDARDS COMMITTEE.

S. A. E. Standards

Their Value, Recognition and Future Development

By B. B. Bachman[1]

AFTER outlining the manner in which the prophetic vision of the men who organized the S. A. E. Standards work has been fulfilled as regards their faith in the growth of motor-vehicle transportation and the utilization of standardization to promote its development most beneficially, the author alludes to the creation of the Standards Committee by the Society and the carrying forward of its work through 11 years as being monumental in character and follows this with a statement of four special reasons why there is a lack of understanding and in some instances an antipathy to this work.

Discussing each of these reasons with a view to eliminating misunderstanding and antipathy, emphasis is placed upon the duty incumbent upon each member of the Society to follow closely the reports of standardization progress made in THE JOURNAL, to criticize, make suggestions and use every effort to prevent any possible stagnation or retrogression in this important work, thus continuing it as a living active influence in the automotive industry.

IN reviewing the history of the Society, we realize that in common with the history of all organizations there are portions that stand out like mountain peaks due to their great importance.

The realization of a few men in the early days of the industry that there was a need for an organization of this character is of course the starting point. However, while there have been and still are numerous problems that can profitably be discussed in the more or less orthodox manner of technical societies, the officers and active members of years past realized that there was need for more than a forum in which opinions and theories could be discussed and contrasted with facts. These men had a vision, almost prophetic, of the future of transportation. They realized that for America to compete in the manufacture of the automobile it was necessary for us to use production methods in which the accurate duplication of similar parts in quantities and by tools and machines rather than by human skill would play a large part.

Purchase and Maintenance

They also saw that to develop this mechanism and solve the many problems that would arise it was desirable that the designers' skill and inventive ability be relieved of all unnecessary detail and concentrated on these other vital things. Likewise, in the field of purchasing materials, the difficulty of comparing values and of obtaining materials in accord with complex and widely varying specifications, such as would exist if these specifications were the result of individual effort, was recognized. In the field of service and maintenance necessary for a complicated mechanism subject to hard usage and unskilled operation, the need for interchangeability was recognized as a means of reducing replacement stocks and minimizing loss of time in waiting for repair parts.

These vital needs pointed the way to one thing, standards. It is inconceivable, in view of the advantages to be gained, even though the difficulties to be encountered be fully recognized, that there should be any lack of acknowledgment on the part of all that the creation of the Standards Committee by the Society and the carrying forward of the work through 11 years is monumental in character. Unfortunately, we must recognize that such is the case, and in recognizing this fact it seems essential to try to realize why there is a lack of understanding of, and, in some instances, antipathy to this work.

Some of the factors that enter into such an analysis and merit consideration are

(1) Ambiguity, and consequent misinterpretation of the meaning of the word standards
(2) Feeling on the part of designers that adherence to standards hampers the expression of individuality in design
(3) The existence of an opinion that standards remove a valuable basis of competition
(4) Lack of support on the part of the executives of the industry

Lack of Understanding

Taking these up in detail, we find that in the first there is considerable misunderstanding of the word standards and what it means. This is probably due to the wide meaning it has in ordinary usage. There are standards of weight and measurement determined with more or less accuracy that vary with the precision of the instruments used to determine them. There are standards of value that fluctuate with changing conditions. To keep in touch with these conditions, we have exchanges, market reports and the like. It is obvious that in these two illustrations we have widely different characteristics; in one there is a frozen condition resistant to change; in the other a fluid condition subject to almost instantaneous response to current conditions.

Neither of these illustrations adequately represents our case. Standards to us can only mean the setting up of logical formulas describing the specifications of materials or the form and dimensions of products based on usage and experience to a very large degree, and dependent for enforcement on the voluntary acceptance of a majority of interested users. Acceptance of this definition indicates that it is difficult to set up standards in defiance of accepted practice or in prophecy of future development; and, furthermore, indicates the fact that the gradual growth of usage, and not the result of a ballot, determines the standard. On the other hand, we are fortunately not confronted, even in our fast-moving industry, with the need of constant revision to suit rapidly changing conditions.

Individuality in Design

The second condition is one of the greatest obstacles in the way of standards, or perhaps it would be better to say has been, for happily a different attitude is being rapidly adopted. The list of standards should be convincing evidence that no sacrifice of individuality need be made that is not perfectly legitimate to gain other more important characteristics. Where is the rational designer who would voluntarily devote his time to creating clevis connections, carbureter flanges, ignition apparatus appli-

[1] M.S.A.E.—Chairman, Standards Committee, Society of Automotive Engineers, and engineer, Autocar Co., Ardmore, Pa.

cations and similar parts, when he can devote it to other more important considerations?

Commercial Competition

The same general thought applies to the next factor, except that in addition the positive statement can be made that, instead of removing competitive features of value, the use of standards adds them. The question of available replacement stocks at reasonable cost is a vital essential to the growing use of all automotive apparatus. A very large item in the cost is the amount of supplies that must be carried by the dealer to meet requirements. From this consideration alone, though there are many others, the use of standards is justifiable even in domestic markets close to points of production and infinitely more important, even imperative, in foreign markets.

The Attitude of the Executive

This brings us to consideration of the fourth item. It is unfortunate that the beneficent effects of the use of standards is bound up in details that in many instances do not come to the immediate attention of executives. The problems of assigning definite monetary value to the savings effected is difficult for the reason, among others, that these savings are intangible in many cases, start small and slowly, and are cumulative. To illustrate, let us go back 10 years and consider that, due to lack of interchangeability of carbureters and ignition apparatus, major alterations in engine construction were required to change sources of supply in these accessories. What would such a condition be in these later days of large production? Or, let us consider the matter of tires. Memory does not have to be taxed severely to recall the time when a change of either a solid or a pneumatic tire involved a change of wheels as well. Or, take the question of steel specifications. How many times in the past stringent years have the steel-maker and purchaser been enabled to get around a bad corner by the existence of S.A.E. Standard steel specifications?

In these times when economy of manufacture is of supreme importance, it is well worth the time of any executive, no matter how busy, to take a copy of the S.A.E. Handbook, check those standards which are applicable to his needs, find out whether they are being used in his product and if not, learn why.

The Society is a democratic organization. To a greater extent than is possible in any other type of organization, it is free from influences of a commercial character, because it is supported almost entirely by the contributions of individual members and the activities of the organization. We have no means of enforcing standards, nor do we want any of our own, for this is not our province. What we do want is intelligent criticism of our work, and its acceptance and use for what it is worth. This, we believe, is fundamentally the function of trade organizations and executives.

S.A.E. Members' Duty

Now to turn the light inward on ourselves, what should we do in the future to carry this work on successfully? As the Chairman of the Standards Committee for 4 years, I have felt that we must be eternally vigilant to have more and more publicity of the work in progress and consideration and criticism in greater degree by more people to insure the quality of the completed work. I fear that as time goes on, unless we keep ever-mindful of this, our committee work will become humdrum and routine and lacking in vision. I am ever reminded that man to give his best must be spurred forward. No soldier fights who does not hold hatred for his foeman. No one exerts his full strength on a level road. Each member should scan the reports of progress in The Journal and should not hesitate to criticize or suggest. Finally, I believe that the time has come when our Sections should take an active part in the standards work in some way, which is not entirely clear at this time, but which I am confident can be worked out.

In preface, it was stated the standards work was a monument to the Society. Let each member make it his personal business to see to it that this monument does not crumble and decay, but that instead new figures are added to it from year to year so that it may continue a living, active influence in the automotive industry.

AIRCRAFT

We must have an Army; the best Navy and the best Army our resources will permit and the national defense demands. But without an air force both are helpless. Every advance in the art of war has been accepted reluctantly and only after its superiority over old and worn-out methods has been proven on the field of battle, frequently at the cost of empire, often to the retardment of civilization.

In the last 10 years we have spent about $1,897,000,000 on coast defense, which consists of cannon placed in strategic positions. Cannon have been developed for 500 years, but they cannot hit a military object as well as a bomber can at battle range. Cannon can shoot effectively no more than 10 or 15 miles. They are fixed in position, and the enemy must come to them in order that they may be able to act. It takes as long to get a battery firing properly, that is, about 1 hr., as it takes an airplane to fly a distance of more than 100 miles.

At present there are 21 different bureaus of the Government handling air matters, namely: War Department; Navy Department and Marine Corps; Coast Guard; Aeronautical Board, Washington; Army Air Service Experimental Laboratory, Dayton; Bureau of Entomology, Washington; Bureau of Fisheries, Washington; Bureau of Mines, Washington; Bureau of Standards, Washington; Forest Products Laboratory, Madison, Wis.; Forest Service, Washington; International Aircraft Standards Board; Joint Board, Washington; National Advisory Committee for Aeronautics, Washington; National Research Council, Washington; Navy Aerodynamic Laboratory, Washington; Weather Bureau, Washington and principal cities.

The mapping of the whole country can be made by aircraft in a period of 3 or 4 years at a cost of from one-fourth to one-tenth as great as the cost by any other means. Our forests can be patrolled by airplanes and protected from fire better than in any other way. Farm surveys can be made from the air and help to increase our agricultural production; they will show what crops should be raised, what the forestation should be, where water should be encountered and distributed. Aerial surveys can show where power and electric lines, railroads and roads should be run. Hydrographic work along our coasts, reconnaissance of mine areas and unexplored territories can be successfully carried out. A short time ago it was demonstrated that orchards can be sprayed from planes with fluid for killing insects in the minimum time with great success and at minimum cost. Passengers, express, and mail at present constitute 30 per cent of the business of the railroads. In the not far distant future the air lines will be serious competitors.—C. F. Curry.

The Value of S. A. E. Standards

By E. A. Johnston[1]

IN addition to the adoption of S. A. E. Standards that has prevailed in the automotive industry, the author believes that they have a general application that can be utilized to excellent advantage by many other industries and if the managers in these fields realized fully the great advantage of adopting and using the standards in increasing output, decreasing the cost of equipment and reducing inventories, they would contribute their full support to this important work of the Society.

The benefits of S. A. E. Standards are indicated, specific reference being made to splines, bolts and nuts, steel specifications, heat-treatment, bases for the purchase of parts to eliminate controversy, and carbureter flanges. Quotations are made from *Engineering Production* to show that the importance of such standardization is being realized in England. A leading feature mentioned is that S. A. E. Standards provide a standard of measure against which an entire organization can check to eliminate possible controversies between departments.

IN the minds of those who are familiar with S.A.E. Standards and the great benefit to be derived from the intelligent adoption and use of them, there is no question with reference to their great value to industry. While these standards have been adopted generally in connection with the automotive industry, unfortunately they have not yet been utilized to the best possible advantage in many other industries. If the managers of any industry who are responsible for its successful and profitable operation could be made to realize fully the great advantages in the way of increased output, decrease in cost of equipment and reduction in inventories, and the many other benefits to be obtained by the adoption and use of S.A.E. Standards, they would, without any doubt, be glad to contribute their full quota of assistance to this important work of the Society. But, unfortunately, many of these advantages cannot be measured directly in dollars and cents, and, further, standards are frequently adopted by the engineering departments, automatically going into use and resulting in many savings, unknown to the management.

The adoption of S.A.E. Standards provides a standard of measure for the entire organization to check against, eliminating controversy between engineering, manufacturing and other departments, and effecting great savings of time and confusion and reductions in cost.

The Society's standardization of splines, bolts, nuts and the like has enabled the manufacturers of hobs, broaches, taps, punches, dies and other tool equipment to make these up in sufficient quantity to reduce the cost of such equipment, and has resulted in jobbers and dealers carrying this standard tool equipment in stock, enabling the manufacturer to obtain his requirements quickly, conveniently and at a moderate cost.

In England, the importance of such standardization is only just being realized, as is evidenced by the following paragraphs taken from an article by Harold Ensaw in *Engineering Production*.

> Although each application of the broaching process requires considering on its own merits, there is no reason for the numerous variations in hole sizes that exist today, and it is time that a committee of engineers discussed the matter with the idea of formulating a series of standards for broached holes, or alternatively give publicity to and recommend the adoption of the standards in existence in America.
>
> When an automobile firm designs sliding gears or a differential wheel, the dimensions of the holes are first fixed by the designer, and the broach-making specialist is then called upon to manufacture a broach to produce those dimensions.
>
> This method prevents broaches being manufactured for stock, and is obviously a source of inconvenience that could be easily avoided if the hole dimension and limits were standardized. Broach-makers should adopt standards, and their catalogs should contain the details of them. In addition to greatly assisting the user, it is evident that by such an arrangement a considerable amount of expensive tool-making would be avoided by the broach-maker.
>
> Should such standards be formulated, it would be a simple matter to arrange for suitable milling-cutters to be sold along with the broach. Milling-cutters are invariably required for milling the shafts with which the broached parts assemble, and if made by the broach-maker they are more likely to be suitable for the work, as the same relieving tools could be used as in the case of the milling-cutters that are employed for the broaches.

The S.A.E. Standard steel specifications have permitted the steel-maker to reduce the number of steels fabricated to a quantity making possible economical operation and to carrying the steels in ingots, billets and bars to provide for the requirements of the large or small user quickly, conveniently and at a moderate cost. Further, S.A.E. Standard heat-treatments enable the manufacturer to obtain the desired results accurately and without costly experiments.

In the purchase of parts, when S.A.E. Standards are specified there is immediately established a recognized basis for acceptance or rejection, thereby eliminating all controversy in connection with heat-treatment, material specifications, tolerance, etc.

The development of S.A.E. Standard nuts demonstrated conclusively the advantage of greater thickness with small diameter, as compared with less thickness and large diameter, and nut standards developed along similar lines have saved implement and other manufacturers hundreds of thousands of dollars annually; in fact, more than $500 per day for one manufacturer. As another case of the fundamental importance of the S.A.E. Standards, I cite the carbureters on a large number of trucks shipped to Australia that did not prove satisfactory, making it necessary to supply a different type of carbureter, which procedure was, of course, very much facilitated by virtue of the existence of the S.A.E. Standard carbureter-flange.

While some of the automotive manufacturers have been slow to adopt S.A.E. Standards and many of the implement and other manufacturers do not yet understand adequately the great advantages to be gained by adopting them, nevertheless, on account of the great economies to be obtained, these standards will be generally adopted just as rapidly as the managers of industries can be made to appreciate the great value of such action and in due course these managers will contribute gladly a small part of the saving effected for their companies toward the maintenance and increasing scope of the great S.A.E. Standards work.

[1] M.S.A.E.—Manager, gas power engineering experimental department, International Harvester Co., Chicago.

The United States Council of National Defense

charged by the Congress with the coordination of industries and resources for the national security and welfare, and with the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the Nation, hereby

makes grateful acknowledgment of the services

rendered by **The Society of Automotive Engineers** *to its organization, and, through it, to the country, in the course of the Great War.*

Given at Washington, *this twenty-eighth day of June, in the year of our Lord one thousand nine hundred and nineteen.*

The United States Council of National Defense

[illegible] *Secretary of War,* Chairman

Josephus Daniels *Secretary of the Navy*

Franklin K Lane *Secretary of the Interior*

D. F. Houston *Secretary of Agriculture*

William C Redfield *Secretary of Commerce*

W B Wilson *Secretary of Labor*

Grosvenor Clarkson
Director of the Council and of the Advisory Commission

THE HELPFULNESS OF THE SOCIETY IN WAR WORK WAS DUE LARGELY TO ITS ACCOMPLISHMENTS IN STANDARDIZATION

Industrial Standardization

By George W. Watson

SPECIAL attention is called to this exposition of the theory and vital value in practice of intelligent standardization in the motor-vehicle engineering field. It was given in an address to the Institution of Automobile Engineers of Great Britain, of which Mr. Watson is president.

The view is expressed that the energetic manner in which the problems of standardization have been tackled, coupled with the loyal cooperation of the American automobile industry in the use of standards, has done more than anything else to bring about the phenomenal development of the motor car in the United States.

In connection with the indifference of the British automobile industry to standardization, Mr. Watson states that, while most of the engineers recognize its benefits, many executive directors have been, and still are, apathetic, and vote money for standardization more in the spirit of "charity" than in appreciation of the fundamentally important manufacturing phase of the question. The sort of apathy to which Mr. Watson refers exists to a deplorable extent in this Country and must be obviated in substantial degree if obtainable results are to be had. It is the only real handicap to American automotive engineering standardization, that is of material importance in placing this economic work in the very high status of effectiveness that it should attain. It is not sufficiently borne in mind that, as Mr. Watson points out, the principle of standardization has existed since the time when exchange and barter were found to be too inconvenient for the development of commerce, a state of things that now exists in Russia. It is the *recognition of a community of interest* in various trades that makes possible the purchasing over the counter of many articles for personal wear or use, not to mention numberless commodities of general utility, at competitive prices. Practices that are unsound will not, and cannot, endure in the automotive or any other industry. The necessity for standardization is more acute in the automotive industry than in almost any other industry.

It remained for an Englishman to produce perhaps the best written interpretation of Abraham Lincoln. The kind of perspective that made this possible has enabled Mr. Watson to deliver a message that calls to mind the adage that a prophet is not without honor save in his own country. What he has to say should be studied with great assiduity by all who are financially interested in or have at heart the design, production and maintenance of automotive apparatus.

Mr. Watson has not, of course, given a comprehensive statement of the basic immutable advantages of automotive engineering standardization, but he has set forth in a vivid convincing manner many salient points and deduced several of the working principles of sane businesslike procedure in the introduction and continued and increasing use of self-propelled vehicles.

WE are all just now going through a most trying period in our history, and many are the suggested remedies for restoring business prosperity. Many of these are political, some social, and others—many others—merely "froth." I do not propose to discuss any of these contentious suggestions, but will confine my remarks to the consideration of a line of action that, if given our personal and collective effort, gives promise of affording a measure of relief to trade in general and to our industry in particular. I refer to standardization, as may be carried out by the British Engineering Standards Association, in collaboration with this Institution, and every other association, body and manufacturer with any interest whatever in automobiles. The Automobile Section of the British Engineering Standards Association during the past year has been reorganized, and there are now good prospects of something tangible being done which should help to bring down the cost of production of both details and completed machines and again put us on a more equal footing with other countries.

British automobile engineering has had a most interesting and varied career. We have had persecution, disappointments, phenomenal developments and now

stagnation, or something akin to it. Britons may always be proud of the fact that their forebears were among the earliest experimenters in mechanical locomotion on the highway, even if they bow their heads in shame at the memory of the acts of stupidity that crushed those early pioneers by requiring their machines to be preceded by a man on foot carrying a red flag. That act gave to other countries an advantage from which, to my mind, they did not profit to the extent that might have been expected. None the less, they went steadily ahead, and French engineeers particularly produced vehicles, the performance of which ultimately convinced our slow-moving legislators that they could no longer stem the tide of development. Those of us who have been in the industry continuously since its early days following the emancipation of the motor car can now recall with amusement our early experiences, but the fact remains that Great Britain, after a period of disastrous exploitation by financiers, quickly made headway, overhauled and even surpassed the efforts of French, Italian and German engineers, until, just before the fateful year of 1914, our factories were producing the finest commercial vehicles in the world, while many of our passenger cars were likewise unequaled in other countries.

Except in a small measure, standardization in our industry at that time may be said to have been nonexistent. How different now might be the state of industry had we taken up earlier this important aid to development. By the adoption of standards for many details that were of common application we should have been better prepared to meet any sudden demand for increased transport facilities without calling so largely upon the resources of other countries. The danger of this lack of unification, particularly so far as concerned vehicles for military transport, was recognized by many quite early, and with your permission I will quote extracts from an editorial article which was published in one of the motor papers in September, 1910. In that article we read:

CHAOS IN MECHANICAL TRANSPORT

Under war conditions, three-quarters of the existing State-owned mechanical transport would be a delusion and a handicap to any commander: each two or three units would need their own load of spares; no important parts are interchangeable throughout any division of wagons or tractors.

What would be thought if this state of affairs held sway in the artillery? What if a gun-carriage or an ammunition wagon had to be abandoned because some little failure must involve long delay while a part was made and fitted on the march? What if it were the exception for any of the gun mountings and breech fittings to be standardized? Yet, in the growing arm of mechanical transport, at least so far, the necessities of the case have been sacrificed to short-sighted considerations which are wrongly supposed to reflect great financial acumen somewhere!

A Standardization Committee should be appointed, and this should be constituted of members of the Mechanical Transport Section of the A. S. C., R. E. officers, and accredited representatives of all *motor manufacturers* who are prepared to produce machines, suitable for military purposes, in accordance with the Army's requirements under an adequate subvention scheme. Although it would not be in the interests of trade that one type of engine, clutch, gearbox, final drive, etc., should be adopted for all internal-combustion-engined machines, the individuality of the designer would not be smothered by the standardization of many detail parts. In the case of vehicles which are propelled by internal-combustion engines, the following are a few of the parts which might well be made to a standard specification, and, if so designed, they would be interchangeable for all makes of vehicles of the internal-combustion-engined class of a given capacity: *starting handle* and spring; diameters of valves, valve springs, cotters, caps, etc.; cam rollers and tappets; clutch (diameter of plates and number of keyways if of disc type, and diameter and angle of faces if of cone type); shape, size and *disposition of the pedals;* shape and *size of radiator* and bonnet; *working positions of change-speed and brake levers; style and position of sprag,* and means for indicating to the driver whether it is in working position; knuckle-joints for steering-gear, also *knuckle-joints for brake gear;* brake-shoes and drums; pitch, type and ratio of chains and chain wheels; *diameters* and widths *of wheels and tires;* sizes of bearing springs and spring-shackles; sizes of strap bolts for spring; hubcaps; *floating bushes for road wheels;* type and position of drawbar; height of carbureter jet and size of screw thread in base of same; *gasoline and water strainers; gasoline-tank filling caps;* and bolts. It might be possible to standardize the diameter of engine cylinders, and, if this were done, one size only would be needed, respectively, for the big-end bushes, gudgeon-pins and bushes, and piston-rings. In the case of steam wagons and tractors, the same process of standardization might be agreed upon.

Were such a Standardization Committee appointed, we are convinced that nothing but good could accrue to the industry, as well as to the mechanical transport undertakings of the Army. The establishment of bases for repairs and renewals could then be placed on a businesslike footing.

America's Opportunity

Shortly after the period to which I have referred a committee was called together, but the personal element was so strong that only a very meager degree of standardization was agreed upon (those items italicized in the above list), and even these were carried into effect by not more than half a dozen makers. One result of this neglect to tackle the question seriously was that we were unable to meet the immense demand when the call was made, and the condition of partial impotence in which the year 1914 found us gave to Americans an advantage which, coupled with the large measure of standardization they had already adopted, enabled their component assemblers to reap such a rich harvest. We are now paying the bill.

Why We Should Standardize

I have selected the subject of Industrial Standardization for my address for three reasons.

First, because, by the standardization of parts we gain the advantage, through interchangeability, of securing to manufacturers uniform standards of materials and dimensions of parts that can commonly be used, and which, being adaptable to many makes and types of machines, can thus be produced in large quantities by specialists at prices that few individual makers could equal were they making similar parts for their own use only. The user benefits to an even greater extent because, once a standard has been adopted and made widely known, it is possible to buy it in almost every town in the country. Common examples of such standardization are the size of screw-threads found on gas burners and fittings and the bayonet-socket lamp-holders for electric lamp bulbs used in house and factory lighting; just think for one moment of the chaotic conditions that would exist among makers, distributors and users of such fittings were no such standards in existence.

Second, the enormous growth of the automobile industry in the United States of America during the past 10 years is in a very large measure due to the adoption of a wide range of standards for materials and details, and even of complete units, with the result that there are now many powerful and successful organizations at work producing complete and interchangeable components. As a direct result there are also a large number of companies that, relieved of the capital cost of installing special machinery for the production of some or all of the components they need, are able to produce completed cars from components purchased outside in numbers unequaled in this country, even in our largest factories. This collective effort and standardization within the automobile industry of the United States is the real reason why such progress has been made over there, and it has enabled prices to be brought down to the point that puts all other countries out of competition. The American home demand is, of course, very large, and the percentage of exported cars compared with the number that is disposed of in the home market is not very great. This large home demand helps our American cousins to get down to rock bottom so far as costs of production are concerned, but I think it is the energetic manner in which the problems of standardization have been tackled, coupled with the loyal cooperation of the automobile industry in the use of such standards, that has done more than anything else to bring about the phenomenal development of the automobile in America.

Third, there never was a period in the history of the British automobile industry when cooperation with a view to the reestablishment of trade, reduction in costs of production and maintenance and the increase of efficiency were more vitally necessary; for these reasons I feel that we ought to leave no avenue unexplored that gives any hope or promise of successful discovery. Hitherto, British industry has been more or less indifferent to the question of standardization, and while most engineers recognize its benefits if carried out in the true spirit of cooperation, many directors have been, and still are, apathetic in the matter; they vote money for standardization more in the spirit of charity donations than as matters of important business. If only they could be brought to realize that standardization is not only possible, but that it is a business proposition and that its successful prosecution would mean increased dividends, the future of our industry would be assured.

Community Interests

The principle of standardization has existed since the time when exchange and barter were found to be too inconvenient for the development of commerce, a state of things that now again exists in Russia, with the difference that in that country almost every article now has a standard value relative to other articles. It is probable that the earliest standards were coins or tokens. Since those days standards of weight and measurement have been established to meet the requirements of various trades and communities, and without them it would be impossible to conduct any business successfully. It is the recognition of a community of interest by manufacturers in certain trades that enables us to purchase over the counter many articles for personal wear or use, not to mention a thousand and one articles of general utility, at competitive prices. I refer to such articles as boots, gloves, safety razors, bicycles and their accessories, cycle tires and similar articles.

Production in large quantities, with special plant, to agreed specifications for materials, dimensions and performance, is the only sure way of cutting down costs. Every standard, however, must be in accordance with the fundamental needs of an industry, and it must have so much to recommend it that neither producer nor user can afford to disregard it. The mere setting up of an intrinsically good standard is not sufficient; if the community interest has been ignored the labor of standardization will have been in vain.

Industrial standardization, or unification as it might more correctly be termed, signifies the interest of producer and consumer. The personal element, which so far in this country has proved to be the most serious obstacle to the establishment of standards, will assume less importance as the advantages of collective effort are recognized, and individuals will be ready to sink their differences of opinion to benefit the many, and incidentally, themselves. This spirit has proved in the United States to have commercial advantages that were not at first apparent, but are now fully recognized by enterprising firms.

Costs of Planning for Fresh Output

Every manufacturer knows only too well the heavy outlay involved in preparing drawings, patterns, dies, jigs and fixtures for the production of a machine, or part, to a specification that may differ only in nonessential details from another specification to which he may be working for another customer. This outlay, of course, has to be borne by the customer. Examples of these needless differences may be found in every factory where specialized articles are made, as, for instance, pistons, piston-rings, spring shackle-pins, etc. It is such details as these that most urgently call for the adoption of standardization. The requirements of the industry must be unified without hampering invention or destroying the individuality of the designer. Any standard should embody the combined experience of an industry so that it represents the best average practice; it can then safely be used as a purchasing specification. Some men argue that nothing should be standardized until we know everything about the subject, while others hold that, from the first, an industry should have provisional standards which may be revised periodically so that they do not limit progress. I think the former line of thought is to be condemned, as there are some things on which our knowledge may always remain incomplete, but that is no excuse for our continuing to interpret in a dozen or more ways such knowledge as we do possess. Let us get together and see each other's viewpoints, then make the best of our present experience and revise the results as progress and requirements dictate. That is the policy of the British Engineering Standards Association. It does not initiate standards, but undertakes the investigation of any subject at the request of an industry. Before commencing work on any one subject, it calls a representative conference of all concerned to make sure that there is a consensus of opinion in favor of such work being carried out. The British Engineering Standards Association has no power to enforce any standard, but given the good will and cooperation of the automobile industry, I am sure that the past and future work of its many sub-committees and panels can only tend to the advancement of the automobile industry in this country, as the work of the Society of Automotive Engineers has done in America.

It has been said that the Society of Automotive Engineers has been too hasty in arriving at many of its standards, and while it must be admitted that very many and frequent revisions are made by them, I suggest that

this only shows the elasticity of the system of tentative standards. They show the average requirements at any particular period, so that makers of components and accessories and suppliers of materials are enabled to quote on an equitable basis.

What Should We Standardize?

It might be well for us to consider for a moment what we mean by industrial standardization. Do we mean the boiling down into one specification and design for each complete car or truck of any given load-capacity, or, what almost amounts to the same thing, the standardization of complete units from which assemblers can turn out finished vehicles or does it mean the careful examination and standardization of details and materials that have common functions to perform, no matter what type of vehicle is under consideration? The former would almost amount to the production of one type of car or truck only, and would practically mean the standardization of the industry's output rather than the standardization of the materials used by the industry. It would put a scotch on progress and bring an end to that much maligned individual, the designer. I have known heads of companies who would welcome the abolition of new designs on the alleged ground that all factory expenses have their origin in the drawing-office; those are the men who will rush the technical staff into production before a design has been digested thoroughly. They will not recognize that alterations can be made on paper at much less cost than in wood or metal.

Does the British automobile industry desire standardization to be carried so far that all motor vehicles, no matter in what factory they are erected, resemble the continuous products of a sausage machine so far as their similarity to each other is concerned? I, personally, do not think so. The vehicle of individual design will always find a market, and the truth of this can be found on the boulevards of Paris or in Fifth Avenue, where there will always be found an appreciable percentage of distinctive British-built cars occupied by discriminating users. We have the choice of assembling, as the Americans do, and commencing a hopeless struggle to compete with them, or of being satisfied to continue to build vehicles that have an individual touch which appeals to a limited market. Probably we shall do best to take the latter course, but even so we cannot hope to succeed unless we apply modern methods of production. We may not be able to build vehicles in such large numbers as to enable us to compete in every market, but we can produce many commonly applicable details in large enough numbers to insure getting down to rock-bottom costs for a large number of details. This can be effected only if we agree, first, what may be included in those "commonly applicable" details, and, second, decide upon their design, materials, dimensions and limits.

A certain number of useful standards were completed before 1914, including the British standard fine thread, while other useful standards have been evolved during the past six years, including the most valuable efforts of the Steels Committee, and the resulting standards for wrought steels. The sizes of magnetos and many other things of special interest to the industry have been dealt with. Much remains to be done, however, and it can only be carried out with the good will and united efforts of all who have any interest in the industry.

Among the first standards on which we require a decision is that of limit gages. This affects all classes of engineering, and it does strike me as remarkable that, after several years of discussion, the committee dealing with this question does not yet feel equal to the responsibility of declaring what should be the size of a 1-in. hole. May it be smaller or larger than the nominal size, or may the tolerance be only above or only below the nominal? The problem, easy enough on paper, is really a very serious one, and its effect varies in different industries. An alternative system, which is really a combination of both unilateral and bilateral systems, has recently been proposed, and if an agreement can be arrived at by the contesting parties it will pave the way for many other standards, as they all, more or less, call for the determination of limits and tolerances.

This vexed question, which our industries alone can decide, as obviously the British Engineering Standards Association cannot impose any standards upon industry, is the biggest problem we have before us, and it must be solved before any new standards can be presented in a form likely to remain unaltered for any considerable period. Tentative standards, however, can be adopted, and there are now before the various subcommittees suggestions for several such standards. These include a number of small fittings, such as gasoline filters, gasoline cocks, drain-cocks, grease-cups, ball-and-socket joint-ends for control rods and lamp brackets, designs of which have been most carefully considered by the Association of British Motor Manufacturers, a committee of which body has put them forward for acceptance by the British Engineering Standards Association. The whole range of automobile standards is being considered by seven subcommittees of the Automobile Section of the British Engineering Standards Association, and if these are all dealt with in the true spirit of cooperation they are bound to have a beneficial effect upon the industry. It is to be hoped that the work of these subcommittees, the constitution of which embodies representatives of this institution, the Association of British Motor Manufacturers, the Society of Motor Manufacturers and Traders, the War Office and other Government Departments and various users' associations, will not be hampered by attempts to impose personal opinions as distinct from collective experience. I am a member of several of those subcommittees, and I feel that unless each member speaks as the mouthpiece of the organization he represents, instead of confining his remarks to an expression of his personal views, progress will be slow and any resulting standards will be in danger of being disregarded by the industry.

The essentials of successful standardization are, first, a full appreciation of the value and influence that standards can have on the development of an industry, and, secondly, the existence, or the creation, of the true community spirit to attain the ideal, or, failing that, the best workable average for any particular subject. The first of these essentials was given important recognition at a recent meeting of the International Chamber of Commerce held in London, where the members agreed to use their influence to propagate the idea and value of industrial standardization throughout the business world at large.

Standardization of Agricultural Tractors

Up to the present my remarks on the standardization of materials and parts have applied more particularly to such automobiles as passenger cars, motorcycles, omnibuses and various kinds of commercial vehicle, but there is another class of machine a consideration of which the automobile engineer should seriously take in hand without further delay. I refer to the agricultural

tractor. In the realm of agriculture, I believe, we are in very much the same position which in the automobile industry we held during the years 1904 to 1907; that is to say, we are just emerging from the experimental stage, and I am convinced that if this branch of the industry is handled intelligently it will prove to be one of the most useful and profitable ones. The application of motor power to farming has, up to the present, been admitted only on a very small scale, notwithstanding the fact that agriculture can truthfully be termed the basic industry. Viewed in that light, it does seem strange that it should have been carried on for so many years with such primitive implements. America has done more with regard to the use of machinery on farms than any other country, and the number of American-built tractors is very great.

Standardization can do much to advance this important branch of the industry, and I suggest that now is the time for those who are interested in the matter to arrive at an agreement for the standardization of such parts as cleats, clevises, spud attachments, belt speeds, height of drawbar, type of drawbar connection, method of control, carbureter flanges, air-filters, and a host of other matters. The necessity for standardization will be appreciated readily when I point out that the belt speeds on the tractors that participated in last year's trials at Lincoln varied from 1830 to 3760 ft. per min., and in the case of only three of them was the belt speed anywhere near correct with the engine running at its normal speed. As one of the principal things for which belt power is required on a farm is the driving of a threshing machine, it might be expected that the designers, in the first place, would have ascertained whether any standard had been arrived at among builders of such machines, and although so far as I am aware, there has never been any conference on the subject, I am informed by Sir William Tritton that all British steam traction-engines, portable engines, etc., are arranged to drive at a belt speed of 2200 ft. per min., and that this is equally true of German, Austrian, American and Canadian engines, with the result that any make of engine can run with any make of threshing machine. Moreover, all other types of machinery for use on farms and by contractors, such as saw benches, mortar mills and grinding mills, conform to these figures.

In the face of this agreement among builders of agricultural steam engines and machinery, it is difficult to understand how the newly developed internal-combustion tractor has come into being without any consideration being given by designers to this important point. This criticism applies to both British and foreign-built agricultural tractors. The difference among various makers is more pronounced in American-built tractors than in those of any other country.

International Standards

This brings us to a consideration of international standards, and in this connection it is interesting to note that Standards Committees are now at work in no fewer than 13 different countries, and that the British Engineering Standards Association is in close touch with them all. Recently an unofficial conference of all the secretaries of these organizations took place in London, which should do much to promote interchange between these bodies and assist in the important work. International Standardization is by no means a simple problem. There are immense difficulties in the way, and it can only go forward with the greatest caution and with adequate safeguards to British industry. Each country must protect its own trade requirements. It is well to recognize that our manufacturers may soon find that they are being asked to quote for foreign specifications, and for that reason every possible support should be given to the British Engineering Standards Association in its efforts to bring the specifications of all countries into harmony. Such a step can only be to the advantage of our export trade.

Standardization in Germany

In connection with international standardization, we ought to bear in mind that not more than three years ago a Standards Committee of the German industry was formed, and after less than 2 years' work it had published no fewer than 160 standard sheets and had over 400 more in progress. It is also interesting to note that the attitude of the German Standards Committee appears to be the standardization of manufacture rather than that of materials, the idea being the simplification of design so as to save both labor and material. Standards which they have already issued cover a very large field, including tools, gages, automobiles, agricultural machinery, locomotives, window frames, doors, stairs, roofing and a vast amount of other work that is undoubtedly assisting that country more than any other in the process of reconstruction. Technical development east of the Rhine needs to be most closely watched during the next 10 years. We should not forget that it was the cooperation of German engineers and capitalists during the 30 years following the Franco-Prussian War that raised Germany from an agricultural to a commercial nation; neither should we forget that the patience, genius and perseverance that created that change in the economic position of Germany is still alive.

STANDARDIZATION IN GERMANY

STANDARDIZATION has become a national craze in Germany in somewhat the same way as efficiency has in this country, according to the comments of engineers, scientists and manufacturers who have been to Europe since the war. The efficiency of German endeavor, in whatever line applied, is a matter of history, but the standardization idea did not develop into its full intensity until the war period. Now the fight for the world's trade is on, and Germany has cleverly recognized the fact that the country offering a wide choice of products, all of each kind being interchangeable, will have a marked advantage over its competitors on that account.

A national realization of the need for rebuilding its export trade, and of the part that standardization would play in securing it, has resulted in the formation of a national organization that is supported by the country's leading industrial and technical associations. It is analogous to our own American Engineering Standards Committee, but is apparently far more active, not only because of the present situation, but also, in all probability, because of the traditional German tendency toward submission to centralized authority.

England, too, is paying attention to the problem, though not with the same intensity that Germany is displaying. Perhaps some further effort along this line would be advisable in this country, in view of the increasing activity of America in international trade. Even for domestic reasons further standardization in many cases would be desirable and would go far toward the elimination of waste.—*Power.*

The 1921 Standards Committee

IN an issue of THE JOURNAL such as the present one that is devoted largely to the results of standardization both in this country and abroad, it perhaps is not amiss to call attention briefly to the personnel that is responsible for the reports of the various Divisions of the Standards Committee printed elsewhere in this number, and to give some facts concerning the work of the Committee for the year 1921. The Standards Committee as now organized consists of 27 Divisions, made up of approximately 350 members.

In the year now drawing to a close 42 Division meetings were held and in addition there were numerous informal meetings of different Subdivisions. The total cost to companies represented at these meetings was $16,000 or an average to each organization of $136. The estimated cost to the Society was $31,500 and, as the National Automobile Chamber of Commerce contributed $7500 to the work, the grand total cost is approximately $55,000. These figures necessarily cover work on subjects that will not be completed in the present year and also similar expenditures prior to last January for standards adopted this year, so that the figure given of $55,000 is probably a fairly accurate measure of cost of standardization by the Society in 1921. It does not include the time spent by Division members outside of the Division Meetings or that spent by Subdivision members outside of or at Division meetings. The average distance traveled to Division meetings per member is 1365 miles and the total number of miles traveled by all members attending the Division meetings is 191,100.

THE PERSONNEL

Photographs of the Chairman and Vice-Chairmen of the Standards Committee and of the chairmen of some of the Divisions are presented on the following pages. The personnel of the various divisions is given below.

STANDARDS COMMITTEE

B. B. Bachman, *Chairman*
W. R. Strickland, *Vice-Chairman*
W. A. Chryst, *Vice-Chairman*

AERONAUTIC DIVISION

H. M. Crane, *Chairman*	Consulting Engineer
V. E. Clark	General Motors Research Corporation
W. L. Gilmore	Curtiss Engineering Co.
L. M. Griffith	National Advisory Committee for Aeronautics
G. E. A. Hallett	Air Service
J. L. Harkness	L. W. F. Engineering Co.
J. C. Hunsaker	Bureau of Construction and Repair, Navy Department
F. M. Kraus	Bureau of Steam Engineering, Navy Department
L. B. Lent	Formerly of Air Mail Service
G. C. Loening	Loening Aeronautical Engineering Corporation
G. L. Martin	Glenn L. Martin Co.
G. J. Mead	Wright Aeronautical Corporation
W. H. Phipps	Ordnance Engineering Corporation
H. C. Richardson	Naval Aircraft Factory
W. T. Thomas	Thomas-Morse Aircraft Corporation
R. H. Upson	Gardner Moffat Co.
P. W. Wittemann	Wittemann-Lewis Aircraft Co., Inc.
E. C. Zoll	Post Office Department

AXLE AND WHEEL DIVISION

G. W. Dunham, *Chairman*	Savage Arms Corporation
C. C. Carlton, *Vice-Chairman*	Motor Wheel Corporation
T. V. Buckwalter	Timken Roller Bearing Co.
R. J. Burrows	Clark Equipment Co.
J. Coapman	Russel Motor Axle Co.
C. S. Dahlquist	Standard Parts Co.
F. W. Gurney	Gurney Ball Bearing Co.
G. L. Lavery	West Steel Casting Co.
A. M. Laycock	Sheldon Axle & Spring Co.
C. T. Myers	Consulting Engineer
A. L. Putnam	Detroit Pressed Steel Co.
J. G. Swain	Firestone Steel Products Co.
G. J. Thomas	Duplex Truck Co.

BALL AND ROLLER BEARINGS DIVISION

W. R. Strickland, *Chairman*	Peerless Motor Car Co.
F. W. Gurney, *Vice-Chairman*	Gurney Ball Bearing Co.
G. R. Bott	Norma Co. of America
H. E. Brunner	S.K.F. Industries, Inc.
E. R. Carter, Jr.	Fafnir Bearing Co.
D. F. Chambers	Bearings Co. of America.
L. W. Close	Bock Bearing Co.
F. G. Hughes	New Departure Mfg. Co.
G. L. Miller	Gilliam Mfg. Co.
H. J. Porter	Timken Roller Bearing Co.
R. G. Schaffner	Bower Roller Bearing Co.
R. E. Wells	Hyatt Roller Bearing Co.

CHAIN DIVISION

W. F. Cole, *Chairman*	Baldwin Chain & Mfg. Co.
W. J. Belcher	Whitney Mfg. Co.
A. E. Brion	Peter A. Frasse & Co., Inc.
H. F. L. Funke	Herbert F. L. Funke Co., Inc.
J. C. Howe	American High Speed Chain Co.
F. L. Morse	Morse Chain Co.
H. S. Pierce	Link-Belt Co.
L. M. Wainwright	Diamond Chain & Mfg. Co.

ELECTRIC VEHICLE DIVISION

E. L. Clark, *Chairman*	Commercial Truck Co.
Karl Probst, *Vice-Chairman*	Milburn Wagon Co.
G. L. Bixby	Detroit Electric Car Co.
J. G. Carroll	Walker Vehicle Co.
F. E. Queeney	Lansden Co., Inc.
C. A. Ward	Ward Motor Vehicle Co.

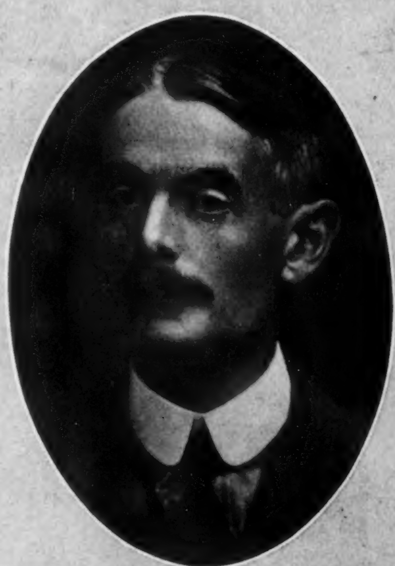
ELECTRICAL EQUIPMENT DIVISION

A.D. T. Libby, *Chairman*	Splitdorf Electrical Co.
F. W. Andrew, *Vice-Chairman*	Eisemann Magneto Corporation
Azel Ames	Kerite Insulated Wire & Cable Co.
W. A. Chryst	Dayton Engineering Laboratories Co.
S. F. Evelyn	Continental Motors Corporation
C. F. Gilchrist	Electric Auto-Lite Corporation
W. S. Haggott	Packard Electric Co.
T. L. Lee	North East Electric Co.
B. M. Leece	Leece-Neville Co.
Charles Marcus	Bijur Motor Appliance Co.
R. G. Thompson	Westinghouse Electric & Mfg. Co.
A. H. Timmerman	Wagner Electric Mfg. Co.
C. E. Wilson	Remy Electric Co.
Ernest Wooler	Cleveland Automobile Co.

W. A. CHRYST

W. R. STRICKLAND

B. B. BACHMAN



H. M. CRANE

F. P. GILLIGAN

RALPH MURPHY

T. C. MENGES

J. J. AULL

BRUCE FORD

E. A. DeWATERS

JOSEPH VANBLERCK

L. S. KEILHOLTZ

W. S. HARLEY

C. E. GODLEY

E. A. JOHNSTON

G. W. DUNHAM

A. D. T. LIBBY

E. H. EHRMAN

J. B. FISHER

A. W. COPLAND

A. K. BRUMBAUGH

ENGINE DIVISION

J. B. Fisher, *Chairman*	Waukesha Motor Co.
R. J. Broege, *Vice-Chairman*	Buda Co.
P. J. Dasey	Midwest Engine Co.
S. F. Evelyn	Continental Motors Corporation
A. F. Milbrath	Wisconsin Motor Mfg. Co.
C. E. Sargent	Research Engineer
Louis Schwitzer	Automotive Parts Co.
E. O. Spillman	Herschell-Spillman Motor Co.
M. J. Steele	Packard Motor Car Co.

FRAMES DIVISION

E. A. DeWaters, *Chairman*	Buick Motor Co.
L. J. Fralick, *Vice-Chairman*	Hydraulic Pressed Steel Co.
C. C. Bowman	Standard Motor Truck Co.
O. B. Harman	Parish & Bingham Co.
E. L. Larson	The Locomobile Co.
W. A. McKinley	Detroit Pressed Steel Co.
F. R. Pleasonton	Parish Mfg. Co.

IRON AND STEEL DIVISION

F. P. Gilligan, *Chairman*	Henry Souther Engineering Corporation
W. C. Peterson, *Vice-Chairman*	Atlas Crucible Steel Co.
R. M. Bird	Bethlehem Steel Co.
A. L. Colby	Consulting Metallurgist
C. N. Dawe	Studebaker Corporation of America
B. H. DeLong	Carpenter Steel Co.
A. P. Eves	International Harvester Co.
E. L. French	Crucible Steel Co. of America
W. F. Graham	Henry Souther Engineering Corporation
H. L. Greene	Willys-Overland Co.
C. G. Heilman	General Motors Corporation
J. B. Johnson	Air Service
F. C. Langenberg	Ordnance Department
C. S. Moody	Minneapolis Steel & Machinery Co.
J. H. Nelson	Wyman-Gordon Co.
G. L. Norris	Vanadium Corporation of America
M. P. Rumney	Detroit Steel Products Co.
C. F. W. Rys	Carnegie Steel Co.
H. J. Stagg	Halcomb Steel Co.
J. M. Watson	Hupp Motor Car Corporation

ISOLATED ELECTRIC LIGHTING PLANT DIVISION

L. S. Keilholtz, *Chairman*	Delco-Light Co.
G. E. Tubbs, *Vice-Chairman*	Alamo Farm Light Co.
F. C. Barton	General Electric Co.
L. F. Burger	International Harvester Co.
T. P. Chase	Lalley Light Corporation
A. S. Denes	S. W. Merritt Co.
G. M. Gardner	Globe Electric Co.
L. W. Heath	Litscher Lite Corporation
S. J. Matthews	Matthews Co.
E. B. Newill	Westinghouse Electric & Mfg. Co.
C. E. Reddig	Western Electric Co.
Samuel Wilbur	Auto-Lite Corporation

LIGHTING DIVISION

C. E. Godley, *Chairman*	Edmunds & Jones Corporation
W. A. McKay, *Vice-Chairman*	H. W. McCandless & Co.
P. F. Bauder	National Lamp Works
F. M. Holden	Cadillac Motor Car Co.
C. A. Michel	Guide Motor Lamp Mfg. Co.
Henry Platz	Gray & Davis Lamp Division of Alvo Mfg. Co.
E. S. Preston	Chicago Electric Mfg. Co.
C. D. Ryder	Corcoran-Victor Co.
C. H. Sharp	Electrical Testing Laboratories
J. C. Stearns	Culver-Stearns Mfg. Co.

LUBRICANTS DIVISION

H. C. Mougey, *Chairman*	General Motors Research Corporation
W. E. Jominy, *Vice-Chairman*	Studebaker Corporation of America
A. P. Eves	International Harvester Co.
W. H. Herschel	Bureau of Standards
W. E. Perdew	Union Petroleum Co.
H. G. Smith	Atlantic Refining Co.

MOTORBOAT DIVISION

Joseph VanBlerck, *Chairman*	Wellman-Seaver-Morgan Co.
H. H. Brautigam, *Vice-Chairman*	Bridgeport Motor Co.
Irwin Chase	Elco Works
G. F. Crouch	Webbs' Academy and Home for Shipbuilders
G. C. Davison	New London Ship & Engine Co.
W. J. Deed	United States Mail Steamship Co., Inc.
H. E. Fromme	Consolidated Shipbuilding Corporation
W. C. Morehead	Great Lakes Boat Bldg. Corporation

MOTORCYCLE DIVISION

W. S. Harley, *Chairman*	Harley-Davidson Motor Co.
C. B. Franklin, *Vice-Chairman*	Hendee Mfg. Co.
A. J. Hall	Cleveland Motorcycle Mfg. Co.
F. W. Schwinn	Excelsior Motor Mfg. & Supply Co.

NON-FERROUS METALS DIVISION

J. J. Aull, *Chairman*	Lunkenheimer Co.
E. Blough, *Vice-Chairman*	Aluminum Co. of America
W. H. Bassett	American Brass Co.
A. G. Carman	Franklin Die-Casting Corporation
D. L. Colwell	Stewart Mfg. Co.
G. K. Elliott	Lunkenheimer Co.
E. S. Fretz	Light Mfg. & Foundry Co.
Zay Jeffries	Aluminum Manufactures, Inc.
A. W. Kinman	Precision Castings Co.
H. C. Mougey	General Motors Research Corporation
Charles Pack	Doehler Die-Casting Co.
H. P. Parrock	Lumen Bearing Co.
W. C. Peterson	Atlas Crucible Steel Co.
W. B. Price	Scovill Mfg. Co.
L. D. Simpkins	National Lead Co.
Samuel Tour	Doehler Die-Casting Co.
W. R. Webster	Bridgeport Brass Co.
E. S. Wheeler	International Nickel Co.
R. W. Woodward	Bureau of Standards

PARTS AND FITTINGS DIVISION

Clarence Carson, *Chairman*	Dodge Bros.
F. G. Whittington, *Vice-Chairman*	Stewart-Warner Speedometer Co.
J. R. Coleman	Selden Motor Truck Corporation
H. S. Jandus	C. G. Spring Co.
W. C. Keys	Eaton Axle Co.
F. W. Slack	Peerless Motor Car Co.
C. W. Spicer	Spicer Mfg. Corporation

PASSENGER CAR DIVISION

Ralph Murphy, *Chairman*	H. H. Franklin Mfg. Co.
R. S. Begg, *Vice-Chairman*	Jordan Motor Car Co.

L. A. Chaminade	Studebaker Corporation of America
H. Clark	Westcott Motor Car Co.
A. M. Dean	Templar Motors Corporation
A. W. Frehse	Standard Steel Car Co.

PASSENGER-CAR BODY DIVISION

E. G. Budd, *Chairman*	Edward G. Budd Mfg. Co.
G. E. Goddard, *Vice-Chairman*	Dodge Bros.
J. S. Burdick	Buffalo Body Corporation
F. C. Chapman	Brewster & Co.
O. H. Clark	Willys Corporation
A. E. Garrels	Studebaker Corporation of America
G. W. Kerr	Racine, Wis.
G. J. Mercer	Consulting Engineer
A. J. Neerken	Hupp Motor Car Corporation
H. C. Nelson	Mullins Body Corporation
Victor Preston	Haynes Ionia Co.
E. G. Simpson	Fisher Body Corporation

RADIATOR DIVISION

J. D. Harris, *Chairman*	McCord Mfg. Co., Inc.
C. S. Sage, *Vice-Chairman*	Sage Radiator Co., Inc.
D. L. Britton	Templar Motors Corporation
H. B. Knap	Packard Motor Car Co.
Charles Oppe	G & O Mfg. Co.
C. T. Perkins	Modine Mfg. Co.
G. H. Pettit	Atterbury Motor Car Co.
G. W. Smith	Nash Motors Co.
K. F. Walker	Fedders Mfg. Co.
E. E. Wemp	Long Mfg. Co.
J. A. White	Harrison Radiator Co.
J. G. Zummach	Perfex Radiator Co.

SCREW THREADS DIVISION

E. H. Ehrman, *Chairman*	Chicago Screw Co.
O. B. Zimmerman, *Vice-Chmn.*	International Harvester Co.
Earle Buckingham	Pratt & Whitney Co.
E. Burdsall	Russell, Burdsall & Ward Nut & Bolt Co.
Luther Burlingame	Brown & Sharpe Mfg. Co.
W. R. Mitchell	National Acme Mfg. Co.

SPRINGS DIVISION

R. A. Schaaf, *Chairman*	Sheldon Axle & Spring Co.
S. P. Hess, *Vice-Chairman*	Detroit Steel Products Co.
H. R. McMahon	Standard Steel Spring Co.
W. M. Newkirk	William & Harvey Rowland, Inc.
Gustof Peterson	Electric Alloy Steel Co.
F. A. Whitten	General Motors Truck Co.

STATIONARY ENGINE DIVISION

T. C. Menges, *Chairman*	Associated Manufacturers Co.
L. F. Burger, *Vice-Chairman*	International Harvester Co.
H. N. Edens	John Lauson Mfg. Co.
W. W. Gore	Fuller & Johnson Co.
H. G. Holmes	Novo Engine Co.
V. E. McMullen	Hercules Gas Engine Co.
I. J. Nelson	Nelson Bros.
L. M. Ward	Cushman Motor Works

STORAGE BATTERY DIVISION

Bruce Ford, *Chairman*	Electric Storage Battery Co.
W. E. Holland, *Vice-Chairman*	Philadelphia Storage Battery Co.
W. H. Bancroft	Edison Storage Battery Co.
G. L. Bixby	Detroit Electric Car Co.
R. N. Chamberlain	Gould Storage Battery Co.
E. L. Clark	Commercial Truck Co.
R. J. Ellis	Seneca Battery Corporation
C. T. Klug	Willard Storage Battery Co.
I. M. Noble	Prest-O-Lite Co., Inc.
A. R. Reid	U. S. Light & Heat Corporation

TIRE AND RIM DIVISION

J. G. Vincent, *Chairman*	Packard Motor Car Co.
A. L. Viles	Rubber Association of America
H. M. Crane	Consulting Engineer
H. H. Rice	Cadillac Motor Car Co.

TRACTOR DIVISION

E. A. Johnston, *Chairman*	International Harvester Co.
John Mainland, *Vice-Chairman*	Advance-Rumely Co.
J. H. Davis	General Motors Research Corporation
A. H. Gilbert	Rock Island Plow Co.
R. O. Hendrickson	J. I. Case Plow Works Co.
M. B. Morgan	Cleveland Tractor Co.
C. B. Rose	Moline Engine Co.
A. W. Scarratt	Minneapolis Steel & Machinery Co.
O. W. Sjogren	University of Nebraska
L. W. Witry	Waterloo Gasoline Engine Co.
G. A. Young	Purdue University

TRANSMISSION DIVISION

A. W. Copland, *Chairman*	Detroit Gear & Machine Co.
A. C. Bryan, *Vice-Chairman*	Durston Gear Corporation
A. M. Dean	Templar Motors Corporation
J. B. Foote	Foote Bros. Gear & Machine Co.
L. C. Fuller	Fuller & Sons Mfg. Co.
A. A. Gloetzner	Covert Gear Co., Inc.
C. O. Guernsey	Service Motor Truck Co.
A. W. S. Herrington	Quartemaster Corps
W. C. Lipe	Brown-Lipe Gear Co.
C. E. Swenson	Mechanics Machine Co.
S. O. White	Warner Gear Co.

TRUCK DIVISION

A. K. Brumbaugh, *Chairman*	Autocar Co.
F. A. Whitten, *Vice-Chairman*	General Motors Truck Co.
W. M. Britton	Britton Axle Co.
G. S. Cawthorne	Master Trucks, Inc.
J. R. Coleman	Selden Truck Corporation
F. W. Davis	Pierce-Arrow Motor Car Co.
H. E. Derr	International Harvester Co.
C. O. Guernsey	Service Motor Truck Co.
M. C. Horine	International Motor Co.
H. B. Knap	Packard Motor Car Co.
A. J. Scaife	White Motor Co.

STANDARDIZATION AND INVENTION

THE inventor of the future will undoubtedly have a harder road to travel to success than his predecessor. Standardization, a big factor in industrial economy, will prevent the easy adoption of something new unless it be a very substantial improvement. This is one of the advantages of standardization. Standardization may be a stumbling block to inventors, but real inventors are then at their best.

Standardization may make a path a little steeper and harder for the man with a good idea, but if the idea and the man are really worthwhile, they will triumph. No artificial barriers can be permanently erected against real improvements, and the standardization that makes it harder for the inventor to obtain recognition will in turn serve to spur him on to achieve greater perfection. Standardization will never stop an Edison, Howe, Whitney, Morse or Bell.—Spencer Miller in *Industry Illustrated.*

Strength Through Standardization[1]

By G. Brewer Griffin[2]

STANDARDIZATION of a product, so far as is possible, directly benefits both the manufacturer and the user, as well as the producer of the raw materials that enter into it. The matter of standardization is a sensitive spot with many engineers. The oldtime engineer felt that unless he could design something that did not exist in the Heavens above, the earth beneath or the waters under the earth, he was not performing in a way that would warrant his title of engineer. Possibly this attitude is all right so long as the product manufactured is sold and serviced solely by the individual or the organization producing it. But just as scon as distribution of such a product becomes general, and the service requirements are national or international, the nearer we approach to accepted standards the better it is for everyone concerned.

Whether the manufacturer is entitled to furnish all service parts of his original manufacture depends upon two things: first, control by patents that would shut out the furnishment by anyone else; and, second, and most important, the worthiness of the manufacturer to receive this business and obtain it by the scope and quality of his service and the relations he maintains with his buyers and users.

Work of Standards Committee

One great good that has benefited the industry is the work of the Standards Committee of the Society of Automotive Engineers. While it has been said that "Standards Committee members spend months agreeing upon some standard, and then hurry back to their own plant and adopt something different," this is not always the truth. It must be admitted that standards have placed the American motor car in the preeminent position it occupies in the world, because the standardization of materials and parts has enabled the steel mills, the nut and bolt manufacturers and hundreds of other similar suppliers to manufacture and place in stock certain of their materials and parts that have been ordered by Tom, but may sooner or later be purchased by Dick or Harry. This has reduced production cost, and the benefits have been given to this industry and in turn passed along to the car owner more than the absence of such standards could ever have done.

Another advantage, to borrow one of ex-President Wilson's expressions, is "the meeting of minds" in association work, particularly where the problems discussed are those that confront everyone present. Out of such informal discussion comes the consideration of standards, whether these standards be employment methods, purchasing methods, methods of operation, cost accounting systems, credit interchange, exchange of experience on materials and treatments, supply sources or contract methods.

Individual Frankness a Benefit to the Industry

Any man who attends a meeting of a group of his fellow manufacturers, keeping in mind that he himself has no particular corner on brains, or any other commodity entering into his business and that he has access to no methods that his competitors cannot just as well have, will learn much and rapidly advance his industry by a frank and outspoken policy in regard to the various phases of his business. This in turn invites like confidences from his associates, and a study of the problem often brings about improved manufacturing methods and better products with it.

In the accessory industry there is, as there has been in years past, a great need of group association, which has heretofore only partially been supplied by the Motor & Accessory Manufacturers Association. Its membership, representing almost every class of industry that deals with automotive vehicle manufacture, aircraft, motorboats and the like, could not in open meetings discuss any particular phase of a problem with a certainty that it would be interesting or helpful to every member present. The result was that individual groups soon associated themselves together outside of the parent Association until it became a case of wheels within wheels without any fixed plan for the heading up of all the branches of the industry and consequently stabilizing the whole.

The Association has taken the one great step forward in offering the opportunity and facilities for its members to operate with and through the parent body, which is the only means by which the various interests are to be harmonized and individual interest broadened. This movement among us is still new, but the interest that has been displayed in it and the groups already formed show that there has been for a long time a need for this action.

Methods Influence Success

The future success and profits of the business in which we are interested is dependent upon the methods we adopt to handle it, and the policies we inaugurate to deal with it. We all have individual opinions; let us make them Association opinions, and in this unity of views and purposes will doubtless lie our future strength and assured success.

I look forward with confidence to the time when we shall work closer and closer with the National Automobile Chamber of Commerce and the Society of Automotive Engineers; our interests are all mutual. It is not unreasonable to suppose that the time may come, after our group plan is perfected and completed, when these present three named bodies will be in fact the three great groups of the one great universal association of the automotive industry.

In individuality there is sometimes strength; in unity there is always strength. I think this is a good slogan for us to use.

[1] From an address before the credit convention of the Motor & Accessory Manufacturers Association.

[2] M.S.A.E.—Manager, automotive equipment department, Westinghouse Electric & Mfg. Co., Springfield, Mass.

DEVELOPMENTS IN PISTON DESIGN

THROUGH a regrettable oversight credit for the material used in preparing the article Developments in Piston Design that appeared on page 199 of the September issue of The Journal was not given to the English magazine *Autocar*. This article was based upon the information contained in the English periodical and the illustration was taken from the same source.

S. A. E. Standardization

By GEORGE W. DUNHAM[1]

CITING examples that show the existence of the idea of standardization in the mind of man almost since the dawn of history and stating that this idea has been a prime factor in the advancement of the world at large, the author acknowledges that standardization does not materialize easily and that it is not always correct in its inception, but believes it an essential to modernism and that it can be developed successfully in an industry composed of independent and competing manufacturers through the necessities and desires of the majority.

This belief is amplified in the subsequent thought and comprises discussion relating to the origin of automotive standardization, non-segregation of engineers, accomplishments, standardization procedure, the wide cooperation with the Society that is now effective and the opinions regarding standardization expressed by representative firms. The author concludes that the standards work should be promulgated as vigorously as in the past and that it should receive even greater and more aggressive support.

STANDARDIZATION may be defined as the adoption of a particular method or means by which to accomplish a desired result; its scope as with most things is relative. It may be limited as to usefulness, but whether it be the accepted method of accomplishment by an individual or many, if it is accepted for usual practice it becomes standard whether dignified by that name or not.

When a mathematician develops a formula, or a manufacturer a special operation or a definite dimension for a certain purpose and adopts it as his way of doing that particular thing it becomes standard with him. If others adopt it, its scope of usefulness increases and if it be of particular merit it becomes a valuable adjunct to the art to which it applies in proportion to its acceptance.

It is felt by some that standardization is something new and perhaps a fad, but it has been with man almost since the beginning and has been a prime factor in the advancement of the world at large. Only through standardization is it possible to obtain the many things requisite to everyday life without having to describe one's wants definitely, and then to institute a search to find that which supplies them. It is today difficult to imagine an existence without an accepted standard of measurement, whether it be that of distance, volume, time, or what not; yet at one time these now simple things placed at our disposal were non-existent, and it is amusing to try to visualize the trials and tribulations of those who first attempted to convince the public of their usefulness. Obtaining wearing apparel by sizes and food in packages in which are given quantities and material of definite quality are conveniences accepted as a matter of fact and of minor detail, but in reality they are of importance as affecting our economic life and are examples of standardization which lie so close to us that we do not realize the work and effort that were necessary to place them at our disposal.

Standardization Inevitable in Modernism

Standardization does not come easily, nor is it always correct in its inception. It is an essential to modernism, especially manufacturing life, and will develop whether a definitely organized effort is put forth or it is allowed to drift aimlessly. Obviously, the former will accelerate the results and the advantages derived from it.

Many commonplace things, good examples of which are the yard and the calendar, were not satisfactory the first time they were attempted, and after many years there is still much discussion as to what should be the universal standard of measurement of distance; yet we would not, in fact could not, possibly discontinue either the millimeter or the inch except through a long period of transition, although it is questionable if one or the other is not inferior.

In an industry composed of independent and competing manufacturers, successful standardization can be developed only through necessity or the desires of a large majority. It is impossible for a small or minor group to force a standard of their creation on any individual or group of individuals, but where the necessity of such a thing exists or a large number of those interested desire it, the practice will become standard whether it is formally developed through concerted action or not. If it is allowed to come about unaided, much time will be required and many unnecessary difficulties experienced before the ultimate is reached, but when a proposition is given study by a highly organized body of interested people, the needs of all investigated, and everyone given an opportunity to voice his opinion and act on the final result, it is difficult to imagine other than a satisfactory and desirable standard except perhaps in rare cases where the necessity or desire does not exist. By such effort properly coordinated there need be but a minimum lapse of time before those interested can realize on the many benefits to be derived. Furthermore, regardless of the number adopting a standard, any individual is naturally free to proceed as he may feel is best for his particular needs, without being any worse off than he would have been had the others not decided to do that particular thing in the same particular way.

In the past there have been isolated cases of manufacturers with a replacement business of such a magnitude that they have deliberately made their products non-interchangeable with those of similar makes even in minor detail to try to insure their control of the sale of spare parts, but almost invariably they have found themselves isolated from the standpoint of possible cooperation and usually been unable to meet price competition on account of their greater cost of manufacture.

Origin of Automotive Standardization

In the early days of the automotive industry the need of a closer contact of the various organizations, especially the engineers, was keenly felt as a means of more rapidly and economically advancing the art. This resulted in what was known as the Mechanical Branch of the Association of Licensed Automobile Manufacturers, made up of the engineering talent of the many companies forming that association. One of the first duties consisted of studying the possibilities of standardization. With an entirely new field in which to work and much enthusiasm almost immediate results were forthcoming, although not always satisfactorily as much had to be learned as to the proper method of procedure. It was found that what

[1]M. S. A. E.—Consulting engineer, Savage Arms Corporation, New York City.

looked very simple was most intricate and difficult of accomplishment. About the same time the Society of Automobile Engineers was formed, embracing all the different activities having to do with the internal-combustion engine. In 1910, after the discontinuance of the Association of Licensed Automobile Manufacturers' Mechanical Branch, it began a study of standardization and, like the Mechanical Branch, found the apparently easy path strewn with pitfalls, which it took years of study and continuous effort to learn how to overcome. All of the records of the Mechanical Branch were turned over to the Society, thus combining the resources of both organizations and advancing the work at one step as could not otherwise have been done during a period of years. This is now ancient history, but has a direct bearing on the situation today as being indicative of the immense amount of thought, "know how" and effort that lies back of the present-day standards work of the Soceity. The amalgamation in 1917 of the Society of Automobile Engineers with the other proponents of the internal-combustion engine, forming the present Society of Automotive Engineers, made still greater results possible in that it brought together with a common aim all those groups of engineers formerly working separately, encouraging more frequent association between them and the executives, production men and salesmen, without whose proper cooperation the best results are obviously impossible.

Non-Segregation of Engineers

It is thought by some that the Society of Automotive Engineers should be composed only of engineers in the strictest sense of the word, and at its gatherings only strictly technical papers should be presented. Unlike most engineering organizations, there is in the Society a great bond of common interest in the advancement of a specific industry, young as yet, the very back-bone of which is standardization. The greatest good is to be accomplished by the direct support of all departments and the consideration of all phases of the problem rather than with a limited and unsupported group as would be the case if the engineers segregated themselves and discussed only technical problems.

Things Accomplished

Standardization as pertaining to the Society of Automotive Engineers obviously has to do with things automotive, and while much has been accomplished without which the monetary values of the various automotive products today would be impossible, there is yet a greater work to be done. Those of the Society who have been active in standardization work to date and those who have given their support can hardly feel other than gratified at the satisfactory progress that has been made. To these men the world at large owes an immense debt, suitable appreciation of which would be difficult to express. Automotive standardization has accomplished much. At one time there were 135 different analyses of steel being used; today this requirement has been reduced to 47. There were originally 88 different sizes of lens, while at present 4 sizes are all that are necessary. The maker of crankshaft grinding-wheels need furnish today but 15 sizes, as against 29 of yesterday, while the number of radii for these wheels has been reduced from 7 to 1. The number of sizes of flexible metal-tubing as required has been reduced from 52 to 28, radiator-cap sizes from 58 to 15, tank-cap sizes from 60 to 15, to say nothing of the excellent and most valuable work on bell-housings, magneto bases, steel tubing, bearing sizes, screw threads, non-ferrous metals and steel and other specifications too numerous to mention. When one considers the enormous saving in tools, simplification of manufacture from the standpoint of handling, increased volume of like pieces, reduction of inventory necessary for production and service, and the ability to obtain material and equipment promptly, one must say a "Big Work Well Done."

The following are some of the many established standards, the years in which they were adopted being specified:

Annular Ball-Bearings	1911
Carbureter Flanges	1912
Electric Incandescent Lamps	1918
Engine Testing Forms	1917
Flywheel Housings	1915
Generator Mountings	1917–1918
Headlamp Illumination	1918
Insulated Wire and Cable	1916
Steels	1912
Lamp Glasses	1919
Lead-Acid Storage-Batteries	1914
Magneto Mountings	1913
Motor-Truck Springs	1915
Non-Ferrous Metals	1911
Passenger-Car Springs	1915
Pneumatic Tires	1915
Rod-Ends and Pins	1911
Roller Chains	1918
Screws, Bolts and Nuts	1911
Seamless Steel Tubing	1911
Silent Chains	1917
Solid Tires	1919
Spark-Plug Shells	1915
Splines	1914
Starting-Motor Mountings	1917–1919
Thrust Ball-Bearings	1917

Procedure

A subject for standardization may be proposed from any competent source. Upon determining the suitability of the proposed subject, it is assigned to a Division or Subdivision of the Standards Committee and data collected. A tentative recommendation is then prepared by the Division or Subdivision and circularized in the trade for comments. If extensive revisions are necessary, the recommendation is again generally circularized and a final recommendation reported to the Standards Committee, which meets regularly twice a year. Upon approval of the report by the Standards Committee, it is balloted upon by the entire voting membership of the Society before publication in the S.A.E. HANDBOOK. Standards may be revised from time to time or may be cancelled.

The different classes of standards are

(1) Those including such specifications as have become more or less permanent through sound or well-established engineering use

(2) Recommended practices including subjects that at the time of adoption are not so well established but for which a definite practice is desired

(3) A class of subjects, published as General Information, usually closely related to the S. A. E. Standards or Recommended Practices, but which are not official recommendations of the Society

The Standards Committee has grown from a relatively small group of perhaps a score to a body in 1921 consisting of 356 members grouped into 27 Divisions. There are two general classes of Divisions, one representing each main automotive group, such as the Aeronautic, the Passenger Car, the Motor Truck and the Motorboat Divisions, and the other representing classified materials and parts such as the Non-Ferrous Metals, the Iron and Steel,

the Parts and Fittings, the Ball and Roller Bearing, the Engine and the Electrical Equipment Divisions. Divisions are further divided into permanent or temporary Subdivisions as occasion may require, each to consider a particular subject assigned to it.

Wide Cooperation

The Society of Automotive Engineers cooperates directly or indirectly with

American Bureau of Welding
American Engineering Standards Committee
American Gear Manufacturers Association
American Institute of Electrical Engineers
American Malleable Castings Association
American Petroleum Institute
American Society for Steel Treating
American Society for Testing Materials
American Society of Agricultural Engineers
American Society of Mechanical Engineers
Automotive Electric Association
Automotive Metal Wheel Association
Chamber of Commerce of the United States of America
Electric Power Club
Gas Engine & Farm Power Association
Grinding Wheel Manufacturers Association
Illuminating Engineering Society
International Acetylene Association
Lamp Standardization Exchange
Manufacturers Aircraft Association
Motor & Accessory Manufacturers Association
Motor Truck Association of America
National Association of Engine & Boat Manufacturers
National Automobile Chamber of Commerce
National Conference on Highway Traffic Regulation
National Electric Light Association
National Implement & Vehicle Association
National Research Council
National Safety Council
Rubber Association of America
Tire & Rim Association
Trailer Manufacturers Association of America
Underwriters Laboratories
Wood Wheel Manufacturers Association

It also cooperates with the following Government departments and organizations:

Department of Commerce, Bureau of Standards
Department of Labor
National Advisory Committee for Aeronautics
National Screw Thread Commission
Navy Department
Post-Office Department
United States Coast Guard
United States Forestry Service
United States Weather Bureau
War Department, Ordnance Department

The Handbook

The Society is, it is believed, the only organization of the kind that has undertaken and carried into effect a loose-leaf form of engineers' reference book. This is of pocket size and known as the S.A.E. Handbook. The sheets, the preparation of which involves a large amount of detail, are furnished to the members without cost in addition to the conventional dues, supplemental and revised sheets being distributed twice a year together with uptodate indices when required.

The Personal Equation

What the development of the next decade or of the next generation will be, none probably can conceive, but it is clear that the essential necessity of cooperative work will be more and more appreciated. No one can reach his attainable development intellectually or professionally without sharpening his wits through much contact with men in and out of his own station of life. It is often said that those who give shall receive, and it is indicated strongly that those who do not give to others in some material degree the benefit of their practical and scientific experience, never receive as much as they could and should, and they can never be assured of being right in deductions as to data that they endeavor tenaciously to develop and hold exclusively.

Opinions Expressed

Replies to inquiries sent recently to prominent executives and engineers in the automotive industries have shown that the monetary saving effected by the use of S.A.E. standards is inestimable. The following statements have been made in regard to their value.

Peerless Motor Car Co.

We believe standardization to be of great help to the industry, provided the standards are kept uptodate. We intend to continue using them in our products where applicable.

W. R. Strickland, Chief Engineer.

Packard Motor Car Co.

It is perfectly obvious that S. A. E. Standards have greatly lowered the cost of production and that on account of these lower costs manufacturers are able to market their cars at a lower figure. It is my belief that S. A. E. Standards will become more valuable from year to year.

J. G. Vincent, Vice-President.

Cleveland Automobile Co.

S. A. E. Standards are very valuable, especially from a purchasing standpoint, and are of great assistance in design and inspection. They permit absolute interchangeability, which would otherwise be impossible.

Ernest Wooler, Chief Engineer.

International Harvester Co.

The results of S. A. E. Standards, which have been given careful and full attention by competent committees covering all engineering commercial angles, are distinctly valuable. They establish a uniform practice in industry, guarantee confidence in the conclusions reached, and elevate the average output of industry.

We are completely converted to the using of standardized designs, materials, methods and data, as we know these do not necessarily interfere with creative engineering and tend to raise the standards of the machinery produced, as well as reduce costs of production. We can produce a better article at the same cost than we could without standards such as the S. A. E. is developing.

O. B. Zimmerman, Research Engineer.

Minneapolis Steel & Machinery Co.

S. A. E. Standards are of utmost importance from the engineering, production and purchasing standpoints. They are conspicuous among the greatest achievements and most valuable assets of the Society and the automotive industry.

A. W. Scarratt, Engineer.

Splitdorf Electrical Co.

S. A. E. Standards have been of great value to the industry. There is still much to be done.

A. D. T. Libby, Chief Engineer.

Brown-Lipe Gear Co.

We believe that S. A. E. Standards are of marked value and that they effect large savings. We will continue to use them wherever possible.

A. E. Parsons, General Manager.

Timken Roller Bearing Co.

The use of standards has the effect of reducing the cost of manufacture and therefore reducing the cost of

automotive equipment. We feel that the greatest benefit has resulted in the standardization of tire sizes, bolts, nuts, lock washers and in general those fittings that are used by practically all manufacturers and do not in any way detract from the individual car by their adoption and use.

T. V. BUCKWALTER, Chief Engineer.

Standard Steel Spring Co.

Standardization is by far the most valuable work of the Society. I really do not know how to express this in dollars and cents or in percentage, but I do know the saving due to the adoption of standards is enormous.

H. R. MCMAHON, President.

Russell Motor Axle Co.

We believe that the adoption of S. A. E. Standards reduces manufacturing costs, makes possible sources of supply for small parts at lower prices, and adds to the prestige of any concern adopting them.

J. COAPMAN, Chief Engineer.

Timken Detroit Axle Co.

It would be quite impossible to put down in definite figures all the financial advantage accruing from the S. A. E. Standards. It no doubt has been very considerable and has of course affected our product although not to such a great extent possibly as in the case of the automobile manufacturers.

The S. A. E. HANDBOOK is probably the most used handbook among automobile designers. The writer is continually turning to it for information, and prefers it to any other handbook we have for general work.

H. W. ALDEN, President.

CONCLUSION

It is hoped that this article will serve to stimulate thought which will result in further appreciation of the value of S.A.E. Standards as they exist at present, and of the necessity and wonderful possibilities of their future development.

If the combined judgment of practically all the automotive engineers of this Country can be considered a criterion, and surely the remarkable results accomplished prove their ability, one must indeed be courageous to criticize adversely their unanimous support and adoption of S.A.E. Standards.

There is still much to be done that will result in great advancement of the industry and the art. It is most desirable that the Standards work be pushed forward as vigorously as in the past, and that it shall receive even greater and more aggressive support, to the end that the American car and other automotive products shall continue to hold their present enviable position.

DIRECTION-FINDING WIRELESS

THE principal use of direction-finding wireless as an aid to navigation is in enabling the bearing of a vessel in open waters, or when approaching pilotage waters, to be determined from one or more fixed points. When the bearings from two or more fixed points are obtained simultaneously the position of the vessel can be located by the intersection of the bearings. Independent of technical systems, there are three types of direction-finding wireless that may be employed as an aid to the navigation of ships. These are

(1) The direction-finding station type
(2) The beacon station type
(3) The directional transmitting station type

In the first type a vessel transmits signals by her ordinary wireless installation to a fixed station, or stations, on shore that are fitted with directional wireless apparatus. The shore station determines the bearing and transmits it to a ship in the ordinary manner. Two or more stations can be grouped to determine the bearing of the vessel from each station simultaneously, and the intersection of the respective bearings, as transmitted by ordinary wireless telegraphy to the vessel by the master station of the shore group, enables the position of the vessel to be ascertained. In this case the responsibility for the accuracy rests with the station and the vessel herself requires no special direction-finding apparatus.

In the beacon station type the vessel is fitted with direction-finding apparatus by which the relative bearing of one or more ordinary fixed transmitting stations can be determined and the vessel's position located by the intersection of the bearings. These are necessarily obtained relatively to the ship's course at the time and are corrected accordingly. Any known ordinary wireless telegraph station can be used for this purpose, or, preferably, certain stations known as beacon stations may be directed to transmit simultaneously, or successively, prearranged signals on certain wave-lengths at definite times during each hour. Under this system the responsibility for the accuracy of the bearing rests with the vessel, which must have a special direction-finding apparatus on board.

In the third method a rotating directional wireless beam having a fixed angular velocity is transmitted by a specially equipped fixed transmitting station. The rotating beam, which swings round in similar fashion to the revolving beam of a lighthouse, has a sharply-defined zero position which passes through north and south at given times. Knowing the angular velocity of the beam, and by observing the time-interval between the given times at which the zero passes through north and south and the time at which the zero signals are received in the ship, the bearing of the station can be determined. To insure that the watches in the transmitting station and the receiving ships are synchronized the station transmits a timing signal before commencing the rotating beam. To avoid calculation in the ship, and to obtain greater accuracy, a special watch, the face of which is marked in degrees, is required on the ship, and the scale corresponding to the angular velocity of the revolving beam. If this watch is started at the moment indicated by the timing signal, the bearing in degrees of the ship from the station can be noted from the watch at the moment when the zero signals are received. This bearing can be checked with subsequent zeros. In this method the responsibility for the accurate determination of the bearing rests entirely with the officers of the ship.

As to the reliability of bearings obtained by the methods outlined above errors may arise from two causes; first by mistakes in the estimation of the bearing on the part of the operator of the direction-finding receiver; and second, by the direction of the arrival of the waves at the receiver being distorted from the direct line joining the transmitting and receiving stations. With regard to the first, practice and experience are essential. Assuming that the directional set has been calibrated and the apparatus and aerials are well maintained, the maximum error in fixed stations with practised operators can be taken as 2 deg., and the average error as less than 1 deg. In ships' sets with small aerials the average error is slightly greater. Errors due to wave distortion are negligible by day when the bearings are over water. Bearings obtained during day and from a station suitably placed so that no considerable line of land intervenes can be accepted as reliable if they are competently taken. Bearings over land, unless it is flat, are less accurate than those over water. This is especially the case with night readings. High land close to and between the transmitter and the receiver is a cause of error. Consequently, bearings should not be obtained when a vessel is close to high cliffs.—J. J. Bennett in *Engineering* (London).

How S. A. E. Standards Are Established

THE Council of the Society appoints the personnel of the Standards Committee and assigns to the several Divisions such work as is considered proper. The Standards Committee is presided over by a chairman and two vice-chairmen who are in cooperation with the General Manager of the Society and the Standards Manager, the two last named being located at the Society offices. Each Division of the Standards Committee operates under its own chairman and vice-chairman and considers matters coming within its particular sphere of work. As a rule, when important subjects are to be considered, a Subdivision is appointed; its chairman is a member of the Division and the other members are selected from the Division or from the industry at large, to secure the assistance of the best-qualified men in that particular field. In selecting members of the Standards Committee, great importance is placed on obtaining men of broad experience and, so far as possible, familiarity with standards work. Many of them naturally come from the companies longer established and better known, but these men are, however, selected more for their personal qualifications than because of the company they may represent.

Authentic standards must be formulated from data and other existing information furnished by the industries to a relatively small group of men sufficiently experienced in such work to analyze them and bring, out of the mass experience of many, a well-defined engineering specification. If this process is not carefully guarded, the resulting standard will be a paper one only. Much valuable time will thus be lost directly, by having absorbed the time that might have been profitably spent in some other endeavor. The success of S. A. E. standardization is attributable very largely to the observance of the foregoing conditions and to the fact that the work accomplished is of sound practical nature, presented in such form as to be readily usable by the men in the drafting room and shop in their every-day work.

Initiation and Procedure

The selection of subjects to be considered for standardization is very important. As a rule, they are scheduled at the request or suggestion of an authority in an industry that will be directly affected. They are then studied with relation to the susceptibility of standardization, the limiting features within which standardization can be accomplished and the probable requirements of the industries that will use the standard. Susceptibility to standardization means that the problem must be of an engineering nature and not a commercial exploitation. The limitations are usually those involving the quantity and quality of materials, the dimensioning of parts making for interchangeability and approved methods of procedure. The suggested subject is referred to the Council of the Society for approval and assignment to the proper Division of the Standards Committee. If the subject is involved, it is first considered by the members of the Division to which it has been assigned and a general plan established outlining the features the standard should embody and what formulative procedure should be followed. The industries are then circularized for data representing current practice and suggestions for consideration by the Division. A tentative proposal is next prepared by the Division and circularized for approval or constructive criticism. If, as a result, extensive changes are made by the Division, the revised proposal is circularized before it is submitted to the Standards Committee and the Society.

Decisions

The Standards Committee as a whole meets twice a year to pass upon the reports submitted by the several Divisions. These meetings are open to the Society members, their guests and representatives of companies that may be interested in the reports submitted. The reports are discussed and usually approved in the original or an amended form. In case of disapproval the report is referred back to the Division submitting it for further consideration and presentation at a subsequent Standards Committee meeting. After Standards Committee approval, the reports go to the Council and the Society in meeting assembled. There they may be amended, but they are usually approved as submitted. Reports may, however, be referred back to the Division at either of these meetings. In the majority of cases reports are approved almost unanimously, but where there is a divided opinion the majority rules. After approval by the Standards Committee, Council and Society meeting, the reports are submitted to the voting members of the Society for approval by letter ballot, before they can become official S.A.E. Standards or Recommended Practices. By the time reports have reached this ballot they have been so thoroughly considered by such a large number of interests that the percentage of negative votes is negligible.

The time required to develop a standard varies from a few weeks to in some cases a number of years, depending upon the conditions encountered. A large amount of office work is required in corresponding with the industries and members of the Divisions, arranging meetings, keeping records and maintaining the S.A.E. Handbook. One of the greatest difficulties is to get a sufficient percentage of replies to inquiries for data or the approval of tentative proposals, to represent the opinions and practices of the industries adequately. Much time and unnecessary labor will be saved in all work of standardization if prompt replies are made to such correspondence.

The Handbook

After the work has reached this stage the most important phases of standardization remain, those of publication and distribution. It is essential that all standards be published in a clear, concise and uniform manner. This was recognized in the beginning by the pioneer members of the Society and its Standards Committee and the present well-known loose-leaf S.A.E. Handbook has proved the wisdom of selecting this form of publication. Little need be said beyond the fact that clear drawings in ample detail with tables and notes are used to set forth the standards and recommended practices. A complete set of all these standards goes to all members of the Society and includes the new and revised standards issued twice a year. The complete Handbook is available to non-members of the Society at production cost and a single copy of any standard can be obtained upon request to the Society. The standards are not copyrighted by the Society and are free for reproduction in any technical or commercial publication, with the simple

qualification that the Society be given due credit. Standards and recommended practices are from time to time reconsidered and revised. The procedure is the same as when the subjects were originally considered. It is important to note in this connection that when any extensive operation that involves a standard is contemplated, such as tooling, it is well to ascertain whether that standard has been revised or is under reconsideration.

INTERNATIONAL STANDARDS

The value of accepted standard dimensions throughout the trade in all branches of manufacture is being recognized more and more every day, and some good work has already been done by the Standardization Committee for the British automobile industry as regards the standardization of tires and rims, which should bear fruit more heavily as the years roll on. In America standardization is much more generally adopted throughout the automotive industry than in this country. In the United States manufacturers are more ready to appreciate the value of such organization and are less conservative than we are, and although this last characteristic of the British people is in many ways gradually being broken down, it is still more or less prevalent among us.

The value of accepted standards is becoming universally recognized, and while we have our Standards Committee of the Society of Motor Manufacturers and Traders at work on English standards, in America the Society of Automotive Engineers has its Standards Committee working out American standards. This committee has done much more than ours, so that many parts are standard throughout the American trade, the dimensions of which in this country differ with every make. Thus in the United States, the wheel track throughout the industry is the same, with the consequence that axles also are all of the same length, with the spring saddles either in one standard position, or adjustable, and, in turn, frame widths are also practically the same, and this uniformity facilitates and cheapens the work of supplies considerably.

Parts and fittings and body makers can standardize on their main dimensions, knowing they will then fit any car, so that not only is the parts-maker saved from finding himself, in the event of losing a customer, with a lot of material on hand that he can use for no one else, but it makes the car manufacturer who buys such parts safer and more independent, as in the event of failure of supply, unsatisfactory quality, or other difficulty arising, he can take the standardized product of another maker and know that the parts will fit into his own chassis plan.

Similarly, the work of the repairer is enormously facilitated, as, in case of an emergency, if parts belonging to the particular make of car are not available, in a large number of cases spares for other cars will either fit or can be adapted with very little alteration. With all axles of the same length, for example, almost any standardized axle could be used to get a broken-down car going again, whereas, with British cars, if a car came in, for example, with a broken 54-in. axle, one of 50 or 52 in., intended for another make, would not be of the slightest use.

In a country like the United States, where the distances are so vast as compared with this country, where by aid of the wire and the rail a new part can be rushed through from the factory in a few hours, this sort of procedure is of great advantage. In foreign countries it is infinitely more so and is, I am sure, a very powerful factor in fostering American foreign trade in cars, while the absence of it hampers our own trade, more especially as the standardization of parts in an individual American car, as apart from their general trade standardization, is as a rule carried much farther than with us, so that not only are spares cheaper and more plentiful, but they usually go in with a less amount of "fitting" than do ours.

Now, it is not wise that British manufacturers should handicap themselves in this matter, and my suggestion is that a strong effort should be made to establish, not only national, but international standards. This could easily be started by cooperation with the Society of Automotive Engineers, each country accepting and adopting the standards independently set up by the other where it has none of its own, and seriously discussing those already adopted by each other, where they clash, with a view to agreement, at the same time working together for the future in all new directions.

THE CASE OF TIRES

Take tires, for example. At present we work with the French and make our tires in millimeter sizes, whereas the Americans work in inch measurements. The result is that no English or French standard tire will fit an American car, and no American tire is any use for European machines, so that English makers of tires are compelled to make, not only the European sizes, but the United States sizes as well, or lose a large portion of the replacement trade, not only abroad but in this country. English cars in the Dominions and other far-flung parts of the Empire and elsewhere, often run the chance of finding themselves unable to secure a supply of suitable spares, although there may be plenty of inch-size American tires available, while the agents in those parts have to carry a double stock of tires if they are to be in a position to supply all comers.

Such universal standardization, too, would vastly assist the introducer of new improvements in fittings and accessories and the introduction of such things would be simplified and cheapened. As it is, nearly all new introductions are at once standardized for Fords, because the Ford is not only universal, but Ford owners today form nearly half of the entire motoring community, and, as a consequence, the owners of other cars find themselves unable to obtain many little improved fittings and accessories that the Ford owner has at his command.—Henry Sturmey in *The Motor* (London).

HIGH-SPEED INDICATORS

The optical indicator developed by the General Motors Research Corporation in its laboratory at Dayton, Ohio, is illustrated on pages 321, 322 and 323 of the TRANSACTIONS for the first half of 1920, vol. 15, part 1. The captions appearing under Figs. 2, 3, 4 and 5 of the paper on High-Speed Indicators by Thomas Midgley, Jr., on these pages and a reference in the text on page 321 indicate that this is the optical indicator of the Bureau of Standards. This error, which was not noticed until after this volume of the TRANSACTIONS was printed, is of course obvious to anyone familiar with the recent developments in indicators since the Bureau of Standards instrument is not of the optical type but employs a diaphragm of the balanced-pressure type in connection with a telephone receiver and an electric contact point, as is described and illustrated on pages 326 and 327 of the said volume of TRANSACTIONS.

Automobile Standardization in Great Britain

By A. A. Remington[1]

THE *Motor Trader* of London, in which the following article appeared, states that there is a distinct tendency toward whole-hearted support of automobile standardization in Great Britain, and that the author is known throughout the industry there to be qualified technically to express an opinion on the matter. Mr. Remington asserts that the fear that standardization may in even the slightest degree result in the hampering of design is absolutely groundless and that the advantages of standardization are inestimable. Practically all of the arguments advanced in the article are not only very familiar to, but have been believed in for many years by, most of the members of the Society, as is obvious from the existence of the hundreds of S.A.E. Standards. In reflecting a gratifying state of affairs with regard to the attitude toward automobile standardization in Great Britain at this time, Mr. Remington gives a forceful and rather comprehensive statement of the principles underlying the conduct of the standardization work of the Society in the last decade.

THE comparative absence of standardization in the automobile industry in Great Britain, and the high pitch of efficiency to which it has been carried in this industry in America, has frequently been the occasion of comment. It is curious that while in Great Britain we have had for many years the British Engineering Standards Association carrying out standardization of all descriptions for our various engineering industries, automobile standardization has in the past been comparatively neglected, whereas in America, where there has until recently been no equivalent standardizing body, automobile standardization has proceeded apace.

It has been suggested that automobile standardization here would until now have been unwise, as we in Europe, and perhaps more particularly in England, are more individualistic, and that standardization would have had the result of impeding design and causing a general deterioration in quality, but this argument is based on a false conception of what standardization is and what it accomplishes.

Result of Industrial Conditions

True, due to the very different conditions obtaining, the effect of standardization would not be precisely the same as in America; the conditions of industry are far from the same, and the needs in consequence different. In America the necessity of obtaining quantity production to fill the factories and of enabling a competitive article to be produced notwithstanding the high rate of wages and also of producing components at specialized factories and assembling them at other plants with the same object in view, in a large measure compelled standardization, and it is probable that the comparatively complete system of standardization was a direct result of the conditions of industry rather than the reverse.

In this country some of the results of the comparative absence of standardization can be seen in the fact that until recently the bulk of the trade has been in the hands of firms with large and ever larger factories, turning out, for the size of the plant, a comparatively small output. The reason is to be found in the necessity for each firm to make all its own parts, and in some cases even its own castings, because, mainly through lack of standardization, its designs and specifications were peculiar to itself, and therefore if it bought the parts outside it was simply a case of giving away all or most of the profit on that part of the turnover. Therefore, as British firms got richer they tended to install more and more plant and more and more departments, so as to keep as much of the profit as possible.

Benefit to the British Industry

At the present moment there is a distinct tendency for the pendulum to swing in the other direction, due possibly to financial conditions, and in consequence we find a tendency to take more interest in standardization. Is it conceivable that the earlier establishment of British automobile standards would have been detrimental, whereas their establishment now will be beneficial? Cooperation between the responsible technical officials of the firms comprising the industry, in a standardization committee, would at any and all times benefit the industry as a whole, and the results of the free cooperation in America in this manner should have the effect of dispelling any fears that may exist that the resulting loss of time at the works and the valuable secret or exclusive information that may be given away operates to the detriment of the individual firm in any way.

Standardization covers several distinct categories, the most important for the automobile being:

(1) The complete standardization of small parts, such as bolts and nuts, pipe unions, greasers and possibly such parts as valves, levers, etc., both as regards dimensions and quality, so that they can be made in large quantities by specialists, at a lower price and more uniformly than would be possible for individual designs and individual firms

(2) The standardization of certain ruling dimensions so that parts not identical in all respects can yet be interchanged, and also so that units will fit when brought together. For example, magneto bases,

[1] F. M. S. A. E.—Past-president, Institution of Automobile Engineers and formerly chief engineer, Wolseley Motors, Ltd., Birmingham, England.

drives and platforms, road-wheel centers and hubs and electrical fittings

(3) The standardization of qualities and tests of materials, so as to avoid the multitudinous specifications, all different, that are otherwise inevitable and which result in so much confusion and mixing of materials, with disastrous results at times; the impracticability of carrying stock with the certainty of a call for it, and the necessarily high prices occasioned by manufacturing in small quantities to special orders and specifications

The fear therefore that standardization may in even the slightest degree result in the hampering of design is absolutely groundless. Engineers will, in fact, by suitable standardization be relieved, for good, of much detail work that is now unavoidable, and so have more time and energy left to devote to real design; although perhaps in the earlier committee stage, while our standards are being established, this will not be apparent, as the work will at first occupy a considerable amount of the time of our engineers. This, however, must be faced, as it was, and still is, in America, well knowing that the immediate advantage of cooperation is by no means inconsiderable and the ultimate advantages of the resulting standardization inestimable.

In considering the possible advantages to be gained by standardization, would anyone today suggest that the standardization of screw pitches and form by Whitworth was anything but good? Yet there was a time when engineers of a certain school thought it in their interests not to use the standards, and Whitworth did not get the interest he deserved taken in his standardization schemes for a long time.

If the same attitude prevails in any quarters today, it may be of interest to take a few concrete cases out of the many that are sure to come before our various committees in the near future.

A Means to Lower Prices

Is there any risk of the fettering of design, should a committee of first-class technical men meet and settle, once and for all, the best material or materials for piston-rings, and the best dimensions and tolerances for rings of different diameter, so that in the future all makers using a ring of a certain diameter can use identical rings of the most suitable material and proportions, as decided by those best qualified to judge; will be able to buy these rings at a lower price than they could make them for, because they will be made in larger quantities; will get better deliveries, because they will be made for stock; and will be relieved of all the trouble and expense of design, experiment and research in regard to this detail in the future?

A number of parts come in a similar category, parts for which there is a correct proportion depending on unalterable conditions, and where individuality in design is only the result of ignorance due principally to a lack of analysis and research, and is in reality only a relic of rule-of-thumb methods.

Of course, the committee would meet from time to time after the establishment of the standards to insure their being kept uptodate in regard to new sizes and such matters.

Can anything but good result from the standardization of qualities and tests for materials at the hands of committees composed of the men having the best knowledge of the materials in question, their qualities and uses? This class of standardization, as already pointed out, does not tie the designer's hands but puts before him clearly in specification form what materials of the class he considers he requires are obtainable, and what results can be expected from them, without his having to search the markets and make a choice from many materials, all perhaps slightly different, any of which would meet his requirements.

An Example of Its Effect

The ways in which standardization helps industry are multitudinous, but let one more example suffice. Standardized materials put all suppliers on an equal basis for comparison, and so bring the question of efficiency to the fore, and it will be found that quality and uniformity or reputation will tell more than ever, because the user will be able to compare the goods he buys on an equal basis, and there will therefore be no tendency for standardization to have the effect of only permitting the just-good-enough at the lowest price to suffice.

Now that interest is reawakened in automobile standardization, late though it may be, it is to be hoped that all will do their best to make up for lost time and do all in their power to assist forward the good work by either practical or moral support. Many engineers and technical experts will be found only too willing to assist, and it is to be hoped that their efforts will not be frustrated by lack of support and facility, occasioned by the fear of partial loss of individual services at the works or of a certain amount of so-called exclusive information on the part of their employers.

The aircraft industry set a great example in the war under a pressing necessity, and the automobile industry is today, perhaps to a large extent unknowingly, benefiting from this work; but many of the specifications are not directly applicable to the automobile, although they are capable of forming a most useful basis and so of saving the automobile standardization committees an enormous amount of time and trouble. The fact of carrying out this work through the British Engineering Standards Association will render all this knowledge available to the automobile committees as well as give them the benefit of all the knowledge accumulated by the Association as to the best way of carrying out this sort of work.

SIMPLIFICATION

SIMPLIFICATION is probably one of the most important means of cutting production cost, but it cannot be accomplished by the individual manufacturer without the whole-hearted support of the financial, sales and production executives. To obtain the greatest reduction in cost it is necessary that such simplification be carried beyond the plant of the individual manufacturer, until, by cooperative effort, a National simplification is accomplished that will react with tremendous advantage to each manufacturer. Such cooperative simplification, or standardization, between manufacturers is carried out most advantageously by trade organizations.

Decreasing Production Costs Through Standardization

By W. D. PARDOE[1]

THE author relates experiences concerning actual benefits obtained by standardization in manufacture in the plant that he manages. The instances cited include clutch facings, brake blocks, radiator hose, tire sections furnished as tire samples to dealers, tire sizes, brake-lining and flexible-coupling discs. The methods used in classifying and standardizing are recounted and the resultant improvements due to this and to S. A. E. Standards are stated in connection with each product.

The savings in cost are indicated, as well as other benefits. The possibilities of further standardization along the same lines are said to be almost unlimited. It is recommended that a standard test for brake-lining be developed, a further desideratum being that costs be decreased by the use of more efficient methods of manufacture and the introduction of labor-saving machines, rather than by lowering the quality of the raw materials used in the fabrication of the product.

OUR inventory of 1918 disclosed that we were fabricating 145 different articles, but that our production of some of them was so small and our margin of profit so slight that it was obvious that they were being manufactured at an actual loss. We found that we were making approximately 170 different sizes of clutch facings and brake blocks; the majority in small lots for individual customers. Each size in the process of manufacture, however, necessitated individual mold equipment and a substantial investment therein. It was evident that some steps should be taken to standardize the sizes of clutch facings, especially as there was only a slight variation in the outside and inside diameters and the thickness of many sizes. Many of the differences in thickness, though very slight, did not permit standardization of the thickness of the material, requiring a resetting of the cutting machines, owing to the variation of the flange width and other production elements, with the resultant decreased production volume.

The facing sizes have now been classified into active and inactive groups. We, of course, do not venture to say that we will not make this or that size of facing because it happens to be in the inactive group and therefore not standard with us, but we try to determine the cost of production before making our decision. We have found that when we outline to a customer that it is to his advantage to use a standardized product, in the majority of instances he is willing to accept it in preference to a non-standard article. The Transmission Division of the Society recognized this situation and has formulated a recommendation[2] which will be submitted for consideration at the Standards Committee meeting in January. The adoption of this recommendation will aid greatly in the solution of the individual standardization problems of all companies manufacturing clutch facings for single-plate and multiple-disc clutches.

CLUTCH FACING STANDARDS

The Transmission Division proposes the adoption of 18 sizes of multiple-disc facing and 6 sizes of single-plate facing, making a total of only 24 sizes, as compared with 45 sizes that were previously used in different clutches. If these standard sizes are adopted, this will result in a reduction of the capital invested in mold equipment, greater production and demand and a better and more uniform product. This will be reflected in reduced costs to the clutch manufacturer.

Standardization of parts and materials permits the simplification and the standardization of each operation in their manufacture. The operator becomes more skilled in the performance of any given operation, owing to greater experience in longer runs; less time is lost in changing over the machines for special work and the cost of production is reduced materially as a natural consequence.

Standardization has enabled us to increase our radiator-hose production threefold with exactly the same equipment. Prior to the inauguration of our simplification program, we made a great variety of styles, lengths and sizes of hose. Much of the increased production obtained is due to the elimination of the necessity of changing over the machinery to produce first one size and then another. Prior to this standardization of radiator hose, an automobile manufacturer induced us to make hose with the name of the car molded on each piece. This not only increased the cost, but slowed up production to such an extent that we were unable to make prompt shipments.

As an example of the savings realized by standardization even in the case of samples, we found that tire sections furnished to dealers were not standardized as to length. Some of our dealers required a 4-in. section, others a 5-in., while still others were not content unless they were furnished with 6-in. sections. The object in having the longer samples was to show the non-skid design of the tread, but this could be shown by photographs and the shorter section would show the thickness of tread, number of plies of fabric and other details of construction. We standardized on a 2-in. section for the non-skid and a 1-in. section for the ribbed tread, which resulted in a saving that has amounted to $5,000 per year.

TIRE STANDARDIZATION

During the war, through the efforts of the War Industries Board in cooperation with the Rubber Association of America and tire manufacturers, odd-size tires were practically eliminated. Table 1 shows the sizes that were called for and considered more or less standard sizes in 1917. As a result of this wartime standardization and subsequent standardization by the Society of Automotive Engineers and other interested organizations, the list of standard pneumatic-tire sizes will be reduced to 9 sizes for passenger cars and 9 for motor trucks in case the recommendation[3] of the Tire and Rim Division

[1] Factory manager, Thermoid Rubber Co., Trenton, N. J.

[2] This recommendation is printed in this issue of THE JOURNAL on page 433.

[3] This recommendation is printed in this issue of THE JOURNAL on page 432.

is favorably acted upon at the January Standards Committee meeting.

TABLE 1—NOMINAL TIRE AND RIM SIZES USED IN 1917

28 x 3	32 x 4	34 x 4½	36 x 5
30 x 3	33 x 4	35 x 4½	37 x 5
30 x 3½	34 x 4	36 x 4½	37 x 5½
31 x 3½	35 x 4	37 x 4½	38 x 5½
32 x 3½	36 x 4	33 x 5	36 x 6
34 x 3½	32 x 4½	34 x 5	38 x 7
31 x 4	33 x 4½	35 x 5	40 x 8

We try to discourage the sales of non-standard tires by making them non-cancellable. This tends to reduce such sales, and eventually the salesmen will not push a non-standard size because of the sales resistance. Again, we have less mold equipment, less capital involved and less confusion in manufacturing, which is a distinct advantage from the production standpoint.

Much has been done in the way of the standardization of manufactured products, but the possibilities of further work in the same direction are almost unlimited. The S.A.E. Standard for brake-lining[4] specifies both the width and the thickness tolerances. As long as we manufacture to these tolerances, every operation runs efficiently. However, when we receive an order for 16,000 ft. of 2 x 3/16-in. brake-lining not to vary more than 0.005 in., we must start with the preparation of special asbestos-yarn and the manufacturing department must follow this particular order through in detail, giving very careful attention to the weaving, frictioning, making, rolling and pressing of the lining. When finished, it must be given painstaking inspection. All of this special attention requires time, increases the cost and affects production seriously.

Brake-Lining Tests

Standard methods of testing are very desirable in that both manufacturer and customer can check the product furnished. Practically all manufacturers now use methods developed in their own laboratories for testing brake-lining; and of the many machines used for this purpose no two are alike, so that it is impossible to compare results obtained in different laboratories. Inasmuch as standard methods for the testing of steel, cement and other materials have been developed satisfactorily, why should not a standard test for brake-lining be developed? Believing that this is feasible, the Society's Subdivision on Brake-Lining, working in conjunction with the Bureau of Standards, has had several meetings to develop a machine that will be inexpensive and at the same time give the desired information. The results obtained to date indicate that in a short time a satisfactory standard method will be adopted.

Flexible-Coupling Discs

Standardization of flexible-coupling discs should receive serious consideration. Our company has mold equipment for at least 500 active sizes of only slight differences, some having the same outside and inside diameters and thicknesses, but different bolt-hole circles. The Society's Parts and Fittings Division at its September meeting reported the possibility of recommending a complete list of sizes increasing in diameter by ½ in., with two or three thicknesses for each diameter. If this proposed standardization could be carried through, it would assist very materially the manufacturers of this part.

[4]See S. A. E. Handbook, vol. 1, p. C55.

At the beginning of this article I stated that we had been making 145 different articles. We are now producing 35, and there is possibility of further simplification; for example, by the standardization of flexible-coupling discs. We appreciate that all of these parts cannot be standardized at once; time and careful study are required to accomplish the results desired.

Conclusion

During the present period of price readjustment and keen competition, it is important, in fact imperative, that every manufacturer, whatever his product may be, decrease costs. This should be accomplished by the use of more efficient methods of manufacture, and the introduction of labor-saving machines, rather than by lowering the quality of the raw materials used in the fabrication of the product. The importance of standardization as a means of reducing manufacturing costs, of obtaining greater production at less cost, and of attaining a higher quality of goods with less rejections due to defective manufacture, cannot be overestimated.

THE NATURE OF MAN

Each generation of beavers begins where the preceding generation began; that is a law for animals; there is no advancement, no time-binding, a beaver dam is a beaver dam. Contrast this with human life. Man invents and discovers and creates. An invention or discovery or creation once achieved, what happens? Each invention leads to new inventions, each discovery to new discoveries, each creation to new creations; invention breeds invention, science begets science, the children of knowledge and art and wisdom produce their kind in larger and larger families; each generation begins, not where its predecessor began, but where it ended; things done become instruments for the doing of better things; the Past survives in the living achievements of the dead; the body of these achievements, invention, science, art, wisdom, is the living capital of the ever-passing Present, inherited to be held in trust for enlargement and for transmission to Future man; the process is that of time-binding: Past and Future are thus united in one eternal Now owning a law of perpetual growth and continual progress. What is the Law thereof, the natural Law? You see at once what it is; it is that of a rapidly increasing geometric progression. If P be the progress made in a given generation, called the first, and if R be the ratio, then the progress made in the second generation is PR, that in the third PR^2, and that made in the single Tth generation will be PR^{T-1}. Observe that R is a large number and that the time T enters as an exponent, and so the expression PR^{T-1} is called an exponential function of Time. This is an amazing function; as T increases, the function not only increases but does so at a rate that itself increases according to a similar law, and the rate of increase of the rate of increase again increases in like manner, and so on endlessly, thus sweeping on toward infinity in a way that is truly marvelous. Yet that is the law, the natural law, for the advancement of civilization—, immortal offspring of the marriage of Time and human Toil.

The World War was an unforeseen, sudden, cataclysmic demonstration of human ignorance of human nature, a demonstration, pitiless as fate or famine, that human beings have never rightly conceived Man to be what Man is, not a mixture of natural and supernatural nor a species of animal, but the natural agency for those time-binding energies in the world whose peculiar function it is to produce civilization and to do so in conformity with its marvelous law of an increasing function of time.—From an address by C. J. Keyser before Phi Beta Kappa Society, Columbia University.

THE TRUTH ABOUT COMMERCIAL AVIATION

THERE has been on the topic of aerial transportation so much false optimism on one hand and so much needless pessimism on the other that the average person is somewhat bewildered as to whether aviation is coming or going.

The Society, whose membership includes so many of the foremost American designers of aircraft, will hold a series of meetings through its Sections in several cities during the present month at which various speakers will tell what has actually been done both here and in Europe in the way of commercial aviation. Authoritative figures will be given showing the number of planes now in operation, the number of miles flown during the past year, the percentage of successful flights and the number of accidents to planes attending to business as contrasted with the much greater loss of life and limb caused by spectacular stunting or through the use of imperfectly designed machines or the operation of planes by insufficiently trained pilots.

The cost of aerial transport per passenger-mile and per ton-mile will be given. These figures will be obtained from flights that have actually been made on regular schedules both here and abroad.

Reports indicate that the machines of one foreign manufacturer during the past summer made 693 out of 725 trips scheduled; over 95 per cent. More than 160,000 miles was flown with no accidents whatever to cargo or passengers.

The annual report of our own Air Mail Service involves a much greater mileage. Of 7659 trips planned, 7081 were perfectly completed, or 85 per cent. Nearly half of the flights were made under bad weather conditions. A million and a half miles was flown and about 45,000,000 letters were carried.

After recounting what has been done to date, those scheduled to give the talks at the various meetings will discuss what problems are still to be solved. Subjects that will receive attention in this connection are airways, landing-fields, ground organization, legal aspects, radio and meteorological service and the relation of civil aviation to national defense. In connection with this last subject moving pictures will be shown of the recent aerial bombing operations against the surrendered German battleships. These pictures have not previously been shown publicly.

Those who will take part in this national program include J. G. Vincent, conspicuously identified with the Liberty engine; Glenn L. Martin, one of the pioneers in aviation; Ralph Upson, balloon expert; and Assistant Postmaster General Shaughnessy, who will give real information about the Air Mail Service.

The following dates have been fixed definitely:

St. Louis	Dec. 1
Detroit	Dec. 5
Indianapolis	Dec. 12
New York City	Dec. 15
Boston	Dec. 16
Cleveland	Dec. 16
Philadelphia	Dec. 22

Other meetings will be held at San Francisco, Buffalo, Los Angeles, Cincinnati, Detroit and Chicago.

INTERNATIONAL AERO CONGRESS

The Society was officially represented at the International Aero Congress held at Omaha, Neb., on Nov. 3, 4 and 5, by Past-President Howard E. Coffin. In the Pulitzer Race the World's record was broken by several miles, the speed being officially given as over 176 m.p.h. Planes flew to this meeting from practically every section of the Country, and many thousand people were on the grounds during the competitions.

The sessions of the Congress were devoted largely to consideration of the formation of a national aviation body, and the presentation and discussion of reports and resolutions. Final steps were taken in the formation of the National Air Association, the following officers being elected: President, Sidney D. Waldon, Detroit; First Vice-President, Col. R. S. Hartz, City of Washington; Second Vice-President, Eddie Rickenbacker; Third Vice-President, Albert Pond, Lambert, N. Y.; Recording Secretary, Rex L. Uden, Cleveland. A board of governors to consist of 18 men, two from each of the nine Army Corps areas, was created. A committee was appointed for the purpose of discussing with the Governing Committee of the Aero Club of America the possibility of effecting a consolidation between it and the new association.

ON THE R38 DISASTER

AT intervals in the course of every human effort toward progress, moral or physical or mechanical, there befalls a disaster which arrests the attention of the world and causes the faint-hearted to regard it as the end of all things. In reality these disasters cause a temporary check, but ultimately they do good in that they act as a spur to further effort because man will not acknowledge defeat and they provide valuable lessons in what to avoid in the future.

Thus the burning of the Amazon on her voyage to America made many people fear steamship travel. But it made the builders of steamships more determined than ever to succeed, and it taught them valuable technical lessons. Similarly the burning of the Irish Mail train at Abergele caused some people to exclaim that here was the end of these dangerous high-speed expresses. Yet all it did was to lead to improvements in couplings and signals and to improve the running of railroads generally. And the burning of the German Navy's Zeppelin L2, though it frightened those who did not believe firmly in airships, only spurred the German Navy and the Zeppelin company to greater efforts, with results that we in England can appreciate better than anybody else.

It was known that certain girders of the R38 were weak. It was known that the ship "hunted" at certain speeds; that is to say she tried to dive and then tried to rise in successive waves in opposition to her elevator control, which would naturally strain her girder-work. It seems fairly clear, therefore, that either under rudder or elevator strain her girder structure failed.

Naturally the hull would crumple in consequence. The crumpling of the hull would tear or burst the adjacent gasbags and gasoline tanks. The gas, either hydrogen or gasoline or both, would mix with the air and the resultant explosive mixture would be almost bound to catch fire from the engine exhausts, for the men in control of the engines would hardly have time to realize that something was wrong and to stop the engines before the explosion would occur.

In the ordinary way, escaping hydrogen or gasoline, if set on fire, burns and does not explode, as those who have seen burning Zeppelins and kite-balloons know. L2 at Johannisthal, which caught fire in the air, burned but did not explode. Therefore the gas must have been gushing out and mixing with air for some time before it caught fire; which proves fairly conclusively that the breaking of the ship caused the fire and that the fire did not cause the breaking of the ship.

Those facts are at any rate almost indisputable. It would be unsafe and perhaps unfair to hazard any further opinions until the Air Ministry Enquiry Committee publishes its report. Then possibly some new evidence may be forthcoming. In any case it is likely that knowledge of value may be obtained, for it has frequently occurred in the past, in connection with airplane as well as airship accidents, that although exact proof of the cause has been lacking various possible causes have been suggested, which suggestions have led to improvements and alterations of great use thereafter.—*The Aeroplane* (London).

OCTOBER COUNCIL MEETING

THE session of the Council held in Cleveland on Oct. 21 was attended by President Beecroft, First Vice-President Horning, Vice-Presidents Bachman, Johnston and Van Blerck, Councilor Martin, W. R. Strickland, J. V. Whitbeck, A. E. Jackman, E. W. Weaver and O. A. Parker. President Beecroft addressed the members of the Cleveland Section at its evening meeting.

The Meetings Committee reported on the progress it is making on plans for coming meetings of the Society. There was considerable discussion of the series of sessions on civil aviation to be conducted during December by several Sections of the Society and by members in cities where there are no Section headquarters, including St. Louis. A resolution was passed favoring the enactment of the bill introduced by Senator Wadsworth in Congress to create a Bureau of Civil Aeronautics in the Department of Commerce.

Thirty-nine applications for individual membership and five for student enrollment were approved, as well as the following transfers in grade of membership: Member to Service Member, Capt. George E. A. Hallett, Gordon Pennington, Edward A. Sipp; Associate to Member, W. C. Barry, Edward Ropp, F. B. Sexton, E. E. Stephens; Junior to Member, E. A. Ryder, William Taylor, Edgar S. Gorrell; Junior to Associate, J. L. White, J. C. Georg, Melvin Rae Wilcox, Arthur Brandes, A. K. Fleming, Ralph Earl Hitchcock, Reuben Kuempel, James L. Myers, Thomas S. Wilson, Richard T. Robinson, Jr.

Thirty-seven applications for membership were received during September as compared with 88 for the same month of 1920. On Oct. 17 there were 5564 on the rolls of the Society, including affiliate member representatives and enrolled students, as compared with 4994 on the same day of 1920.

SUBJECTS ASSIGNED TO STANDARDS COMMITTEE

Subjects were assigned to respective Divisions of the Standards Committee, as follows:

Emergency Rim-Clamps and Passenger-Car Front-Axle Hubs—Axle and Wheels Division
Breaker Contacts, Generator Strap-Mounting and Magnet Wire—Electrical Equipment Division
Crankcase Drain-Plugs—Engine Division
Tail-Lamps—Lighting Division
Solders—Non-Ferrous Metals Division
Wing Washers—Parts and Fittings Division
Hand Taps and Wing Nuts—Screw Thread Division
Industrial Truck and Tractor Batteries—Storage Battery Division
Three-Joint Propeller-Shafts—Truck Division

RESEARCH MATTERS

In connection with the Research Department, it was reported that it had appeared advisable to complete a general survey of the present research activities and facilities at the disposal of the Society, enough having been accomplished in the preliminary survey to indicate rather clearly the most pressing needs of the Society that can be met by the Department. There is now in progress in a number of laboratories, including those at Massachusetts Institute of Technology, University of Michigan, Sheffield Scientific School, University of Illinois and University of Nebraska, a large amount of very valuable and creditable research that has not come to the attention of the members. Moreover, an unexpected amount of valuable information that has not been made public has been obtained from time to time through researches in the various industrial laboratories. The most immediate need seems to be a more convenient and effective means for the individual engineer in either research or development to learn what has been done and is being done in his own particular line. To this end, the Research Department will make a careful canvass of all research laboratories and all individuals who have information to impart, the purpose being to establish in the office a complete index of projects under way and completed but not published.

The real business of the Research Department is to organize research in such a way as to meet the needs of the industry, and the ultimate aim is to draft a comprehensive program of needed research, to check against this the work already undertaken that shows promise of success, and secure the initiation of such additional researches as may be needed wherever the best facilities are to be had. The first portions of this general program will involve the two general problems of fuels and highways. With regard to the former, a tentative program for the study of the relations between fuel volatility and total consumption was approved by representatives of the American Petroleum Institute and the Society some months ago. This is one phase of the fuel problem that should be undertaken as soon as possible. Considerable very active highway research is in progress at a number of institutions. The Research Department has been asked to take part in laying out a program for the study of highway tractive resistance to be conducted by the Massachusetts Institute of Technology and at Yale University.

ENGINEERING'S VIEW

THAT a proper system of standardization would cheapen motor-car production requires no demonstration. The matter is obvious. We are not prepared to say that the more standardization the more benefit. It would, no doubt, be possible to go too far, but in the early stages certainly the more standardization the more benefit. If steel for leaf springs alone is standard the manufacturer may possibly be required to roll only 10 sections instead of 60. He can thus roll it more cheaply, and it can be bought and sold more cheaply. It would reduce the price of British cars; not much certainly, but cheapness in repetition manufacture is partly obtained by concentrating on details. If brake-shoes were then standardized one would have the cheapening of a further item, and the process could with profit be carried very far.

As the motor-car industry first developed in this country it was largely in the hands of enthusiasts, who were not always engineers, and the value of individuality in car design became over-accentuated. This point of view persists even to this day, and too many makers appear to think that some extra virtue lies in the use of a distinctive detail for which a standard part would be an entirely satisfactory substitute. For a very limited trade and a very limited class of car there is something to be said for the peculiar detail, but if the automobile industry is to take the place its importance deserves in the range of engineering manufacture, it must be realized that the best machine at the lowest price are qualifications far outweighing the value of five-sided nuts or any other distinctive features of such minor importance.—*Engineering* (London).

Reports of Divisions to Standards Committee

THE Division Reports enumerated below will be presented at the Standards Committee Meeting, Tuesday, Jan. 10, beginning promptly at 10.30 a.m. on the fifth floor of the Engineering Societies Building, 29 West 39th Street, New York City. They are published in this issue of THE JOURNAL, sufficiently in advance of the Standards Committee Meeting to permit a careful review of the recommendations and the preparation of discussion by the members of the Standards Committee and others who expect to be present. The reports of the Divisions will be presented at the Standards Committee Meeting in the order in which they appear hereinafter. Discussion of the reports at the Standards Committee Meeting and at the Society Meeting that follows is invited from all who are technically familiar with the several subjects, whether or not they are members of the Standards Committee. All discussion should be to the point and as brief as possible, owing to the limited time available at the meetings for such presentation.

Under the Standards Committee Regulations only members of the Standards Committee may participate in the voting that will follow the discussion of each recommendation at the Standards Committee Meeting. At the Society Meeting only qualified voting members of the Society may participate in the voting.

All subjects passed at the Standards Committee and Society Meetings will be reported in the February issue of THE JOURNAL and submitted to a letter ballot of all the voting members of the Society, unless contrary direction is given by the Council.

The several Divisions submitting reports, and the Subdivisions which in many instances prepared them, have carefully considered their subjects and the conditions bearing on them. It should be borne in mind that the recommendations have been founded on data obtained directly from the industries, but are necessarily compromises in greater or less degree of current practice by individual companies, and involve what may be considered ideal practice so far as this is practicable. It should be understood also that the recommendations need not necessarily be put into practice upon their adoption by the Society, but should be followed by the various industries when changes in design or production make it economically possible to do so.

The members of the Standards Committee, who are selected because of their broad experience and ability to represent adequately the many branches of the automotive industries, have given generously of their time and resources for the standardization work during the past year in face of the serious conditions that have existed. This truly indicates the recognized value of standards, and makes it practically necessary for the managers and executive directors of the industries to keep informed of the work being done by the Society, and to give it due recognition and support by having the standards used in their products as extensively as possible. The manufacturing and sales executives are urged to review the recommendations of the Standards Committee, to bring their points of view to bear in the discussion at the meetings and to facilitate the work of the engineers in the manufacturing of their products by having the standards used as extensively as possible.

AERONAUTIC DIVISION REPORT

TACHOMETER DRIVE

(Proposed Revision of Recommended S.A.E. Practice)

Experience has indicated that the driving element in the present recommended practice, page C75, S.A.E. HANDBOOK, for the tachometer-drive connection at the engine is not strong enough to prevent binding in the tubing due to the tendency of the flexible driving-shaft to untwist, especially in the operation of types of tachometer which turn faster than indicated speed. The Division therefore recommends that the present S.A.E. Recommended Practice for Tachometer Drive be revised as follows:

(1) Change the diameter of the tachometer driving-shaft from 0.152 plus or minus 0.001 in. to 0.187 plus or minus 0.001 in.

(2) Change the drill size for diameter of the hole for the tachometer driving-shaft from No. 20 (0.161 plus or minus 0.002 in.) to No. 11 (0.191 plus or minus 0.002 in.)

BALL AND ROLLER BEARINGS DIVISION REPORT

ANNULAR BALL BEARINGS

(Proposed Revision of S.A.E. Standards)

Last summer a complaint was received from a user that it was difficult for manufacturers building parts to be fitted with ball bearings to secure bearings having bores ground to a sufficiently narrow range of tolerance to obtain the proper fit and interchangeability of bearings on accurately ground shafts.

A Subdivision appointed to investigate this matter reported that accurate measurements made on a number of bearings from each of the different manufacturers as secured on the open market showed that the variation from the nominal inside diameter in practically all cases is from the nominal to about two-thirds of the minus limit, and seldom, if ever, on the plus side of the nominal diameter.

It is felt that as practically all ball bearings used by the automotive industries are made to within a narrower range of bore tolerances than specified in the present standards for annular ball bearings, the tolerances can be lessened without creating any difficulties for the bearing manufacturers.

The Division, in studying the report of the Subdivision, considered it desirable to rearrange somewhat the distribution of the tolerances over the ranges of bearing

TABLE 1—INSIDE DIAMETER TOLERANCES RECOMMENDED

Range of Inside Diameters, mm.	Tolerances, in. Plus	Minus
4 to 25	0	0.0004
30 to 55	0	0.0005
60 to 80	0	0.0006
85 to 110	0	0.0007
120 to 210	0	0.0008

sizes to provide more logical increases in grinding limits with the increases in the diameter of the bore. It is therefore recommended by the Division that the plus tolerance on all types of annular ball bearings be omitted and the tolerances redistributed over bearing bores as given in Table 1.

The recommendation applies to the following S.A.E. Standards for annular ball bearings, printed on the S.A.E. HANDBOOK pages indicated:

Annular Ball Bearings, Light Series	C26
Annular Ball Bearings, Light Series, Extra Large	C27
Annular Ball Bearings, Medium Series	C28
Annular Ball Bearings, Medium Series, Extra Large	C29
Annular Ball Bearings, Heavy Series	C30
Annular Ball Bearings, Wide Type	C31
Annular Ball Bearings, Separable Type	C32
Annular Ball Bearings, Extra Small Series	C33
Annular Contact Ball Bearings, Medium Series	C33a
Annular Contact Ball Bearings, Medium Series	C33b
Annular Contact Ball Bearings, Heavy Series	C33c

CHAIN DIVISION REPORT

ROLLER-CHAIN SPROCKET-CUTTERS

(Proposed Extension of S.A.E. Standard)

The Chain Division recommends the following for adoption as an extension of the present S.A.E. Standard for Roller-Chain Sprocket-Cutters as the importance of standardizing sprocket-cutters so as to make it possible for sprocket-cutter manufacturers to carry in stock a single type of cutter which will cut all sizes of standard sprockets is realized.

> Two straddle cutters shall be used, an *A* cutter having an average pressure-angle of 23 deg. for use where the arc of contact between the chain and the sprocket is fairly large, and a *B* cutter having an average pressure-angle of 17½ deg. for use only where the arc of contact is small.
>
> All cutters shall be marked with the pitch, roller diameter and the range of the number of teeth for which each cutter is designed.
>
> The inside and outside diameters and the keyway dimensions of sprocket-cutters shall be in conformity with the dimensions specified in Table 2.

Standardization of the inside diameter of sprocket-cutters is considered important as determining the diameter of the arbor used; and of the outside diameter because, if too small, the cutter is liable to break in service. The use of too large an outside diameter results in a waste of material and requires more time for cutting the work. The Division gave some consideration to the advisability of standardizing the number of gashes in the sprocket-cutter, as too many gashes decrease its life. It is felt advisable, however, to leave this to the cutter manufacturers so as not to limit individuality of design. The cutter-arbor keyways recommended for adoption are in accord with the standards used by machine-tool builders.

The Division's recommendation for straddle-cutters was made after careful consideration of the relative merits of straddle and space-cutters, one point being that a space-cutter used, for example, on sprockets having 12 teeth would cut teeth with flat crowns, while on sprockets having 17 teeth it would cut teeth with pointed crowns.

In Table 2 the roller diameter and cutter bore dimensions were calculated from the following formulas:

$$RD = 1.2(B + RD + 0.7\,P) + 1$$
$$B = 0.7 \sqrt{\ } (W + RD + 0.7P)$$

where

B = cutter bore
P = pitch of chain
RD = roller diameter
W = width of cutter

TABLE 2—PROPOSED SPROCKET CUTTER DIMENSIONS

Pitch, in.	Roller Diameter, in.	Cutter Bore, in.	Keyway, in.	Cutter Outside Diameter, in.
3/8	0.200	1	5/32x5/64	2 3/4
3/8	0.250	1	5/32x5/64	2 7/8
1/2	0.250	1	5/32x5/64	2 7/8
1/2	0.313	1	5/32x5/64	3
5/8	0.313	1	5/32x5/64	3 1/8
5/8	0.400	1	5/32x5/64	3 1/4
3/4	0.400	1	5/32x5/64	3 3/8
3/4	0.469	1	5/32x5/64	3 3/8
1	0.469	1	5/32x5/64	3 1/2
1	0.563	1 1/4	3/16x3/32	4
1	0.625	1 1/4	3/16x3/32	4 1/8
1 1/4	0.625	1 1/4	3/16x3/32	4 1/4
1 1/4	0.750	1 1/4	3/16x3/32	4 3/8
1 1/2	0.750	1 1/4	3/16x3/32	4 5/8
1 1/2	0.875	1 1/4	3/16x3/32	4 3/4
1 3/4	0.875	1 1/4	3/16x3/32	5
1 3/4	1.000	1 1/2	5/16x5/32	5 1/2
2	1.000	1 1/2	5/16x5/32	5 5/8
2	1.125	1 1/2	5/16x5/32	5 7/8
2 1/2	1.125	1 1/2	5/16x5/32	6 1/4
2 1/2	1.550	1 3/4	3/8x3/16	7 1/8
3	1.550	1 3/4	3/8x3/16	7 1/2
3	1.900	2	1/2x1/4	8 1/4

ROLLER CHAINS

(Proposed Extension of S.A.E. Standard)

The Chain Division recommends that the present S.A.E. Standard for Roller Chains be extended to specify the minimum breaking-strengths based on the formula

Minimum Breaking-Strength in Pounds = 105,000 (Pin Diam.)^2 — 700

It is known that well constructed roller chains will withstand heavier pulling loads than those indicated by this formula, but the Division desires to specify the *minimum* breaking-strengths in order that users having a limited knowledge of the proper application of roller chains may have a reliable guide as to proper chain applications. The factor 700 is included in the formula because the case-hardening of the pin has been found by tests to reduce the strength against shearing by about this amount.

The actual minimum breaking-strengths for the light, medium and heavy series of S.A.E. Standard roller chains calculated by the formula recommended are given in Table 3.

TABLE 3—MINIMUM BREAKING-STRENGTH OF S.A.E. STANDARD ROLLER CHAINS

Heavy Series		Medium Series		Light Series	
Chain Number	Minimum Breaking-Strength, lb.	Chain Number	Minimum Breaking-Strength, lb.	Chain Number	Minimum Breaking-Strength, lb.
30W	940	......	......	......	......
40W	1,850	41W	940	......	......
50W	3,500	51W	1,850	52W	940
60W	5,045	61W	3,500	62W	1,850
80W	9,550	81W	5,045	82W	3,500
100W	14,063	101W	9,550	102W	9,045
120W	19,400	121W	14,063	122W	9,550
140W	25,550	141W	19,400	142W	14,063
160W	32,520	161W	25,550	162W	19,400
200W	63,350	201W	32,520	202W	25,550
240W	91,585	241W	63,350	242W	32,520
320W	163,360	321W	91,585	322W	63,350
400W	235,550	401W	163,360	402W	91,585

The Chain Division also recommends that the thickness of center plates for double, triple and quadruple chains shall be equal to twice the thickness of the inside plates in S.A.E. Standard single roller chains.

ELECTRICAL EQUIPMENT DIVISION REPORT

Insulated Cable

(Proposed Revision of S.A.E. Standard)

The letter ballot of the Society members last July on the adoption of the revised S.A.E. Standard for Insulated Cable, page B33, S.A.E. Handbook, as approved at the Standards Committee Meeting last May, afforded some constructive criticism by one or two members which has since been considered by the Electrical Equipment Division in the preparation of the recommendation now presented.

Criticism was made of cleansing the copper wires in a caustic-alkali solution or hot water and soap, it being contended that such treatment leaves the wire in condition to be attacked by the sulphur in the rubber insulation. As neither of these cleansing solutions is used to any extent, it is thought advisable to exclude them from the specification, and to include carbon tetrachloride which is used frequently.

The Division also recommends that the strength of the sodium-polysulphide solution be definitely specified to prevent the use of a saturated solution, and to make the specification more definite. The remainder of the Division's recommendation includes changes in the present specifications that will eliminate extraneous matter and generally improve the standard.

The recommendation of the Division for revision of the present standard, is:

Section II—Tests

Par. 1—Omit the terms "caustic-alkali solution" and "hot water and soap" and insert the term "carbon tetrachloride." Add the sentence "Care shall be taken to avoid abrasion or scratching of the samples of wire to be tested."

Par. 2—Insert the phrase "having a specific gravity of 1.142 at 70 deg. fahr. (21 deg. cent.)" after the words "sodium polysulphide." In the last sentence omit the words "and which has" and begin a new sentence reading, "The polysulphide solution shall be maintained at a ———".

Par. 4—Omit the second sentence reading, "All wires shall withstand one immersion in the hydrochloric acid without blackening in the sodium-polysulphide solution, and 75 per cent of the wires shall withstand three immersions in the hydrochloric acid without blackening in the sodium-polysulphide solution." This part of the present specification will be covered in the two preceding paragraphs of the standard.

Par. 5—Add the following sentences as Par. 5, "After completing the above operation the samples of wire shall be examined to ascertain, through blackening caused by the sodium-polysulphide solution, whether the copper is exposed. The samples shall be considered to have failed if by such blackening the copper shall be shown to be exposed."

Footnote—Add a footnote referring to Section II—Tests, reading, "This test conforms substantially to that in American Society for Testing Materials Specification B33-19T."

Generator Flange Mounting

(Proposed Revision of S.A.E. Standard)

The Electrical Equipment Division recommends that the present S.A.E. Standard for Generator Flange Mounting, page B17, S.A.E. Handbook, be revised by changing dimension *L*, the length of the shaft-end from the hub to the center of the cotter-pin hole, from 1-25/32 to 1-13/16 in., and by changing dimension *M*, the overall length of the shaft-end, from 1-15/16 to 2-1/32 in. These changes will make the length of the threaded portion of the shaft-end practically the same for both the No. 1 and No. 2 flanges and permit using the same armature shaft-end in either size of generator. The changes also allow the use of a washer between the castle-nut and the face of the gear or sprocket.

Starting-Motor Flange Mountings

(Proposed Revision of S.A.E. Standard)

The Electrical Equipment Division recommends that the present S.A.E. Standard for Starting-Motor Flange Mountings, page B19, S.A.E. Handbook, be revised to specify 7/16-in. drilled holes for the holding bolts instead of 13/32-in. diameter holes which will permit using a more common drill size and give a 1/16 instead of 1/32-in. clearance for the bolts. The change will also facilitate assembling of the starting motor on the engine, which is definitely located by the pilot on the starting-motor flange.

Flexible Steel Conduit

(Proposed Revision of Recommended S.A.E. Practice)

The Electrical Equipment Division recommends that the present S.A.E. Recommended Practice for Flexible Steel Conduit, page C52, S.A.E. Handbook, be revised to conform to the accompanying specification.

The Division's recommendation resulted from criticisms in reference to the present standard adopted by the Society in 1916. It was desired by the Division to base the revised standard on the standard for Insulated Cable that was adopted last July. A Subdivision was appointed which represented the principal conduit manufacturers and a tentative recommendation prepared, this being submitted for consideration at the October meeting of the Electrical Equipment Division. The report was circularized among conduit manufacturers prior to the meeting and is now submitted as the recommendation of the Electrical Equipment Division.

FLEXIBLE STEEL CONDUIT

General Information Flexible steel conduit is recommended for use as a mechanical protection to insulated electric wires, that otherwise would be exposed to injury and shall be of the square-locked type, made by coiling a formed metallic strip.

Conduit may be made of zinc-coated steel or of brass. When made of brass, the dimensions shall be the same as those of steel conduit.

Flexible metallic conduit may be of either the "packed" or "unpacked" type. Packed conduit may have either asbestos packing or cotton packing. Asbestos packing is preferable to cotton when the conduit is exposed to high temperatures.

Flexible metallic conduit shall be designated by nominal inside-diameter and specified thus: "⅜-in. inside diameter, asbestos packed, galvanized steel conduit", or "½-in. inside diameter, unpacked, galvanized steel conduit."

Because of the general construction and flexibility of this conduit, there is a considerable difference in a given piece between the compressed or fully extended lengths. All measurements for length shall be based on the mean or average of the compressed and extended lengths.

Sizes and Dimensions—Table 4 of sizes, weights and strengths relates to packed and unpacked conduit.

conduit. This cannot be considered as an exact test, but it does not require a chemist. With experience, anyone can determine quickly by comparison the amount of zinc coating.

The test solution is to be prepared by boiling pure water with sufficient crystals of chemically pure copper sulphate to give a saturated solution with an excess of copper sulphate when cool. The solution shall be neutralized by the addition of oxide of copper, then filtered and diluted to a specific gravity of 1.186 at 65 deg. fahr. A saturated solution requires about 27 parts of copper sulphate to 73 parts of water, by weight.

To guard against changes in specific gravity or saturation, the solution should not be kept in a room whose temperature falls much below 65 deg. fahr.

Method of Making Galvanizing Test—The solution shall be poured into a No. 1 tall glass beaker of about 2-in. diameter; about 100 c.c. shall be used for test of ¾-in. and smaller conduits, and about 125 c.c. for larger sizes. The same supply of solution shall be used for successive dips of any one sample, but a fresh supply shall be used for each new sample, and the used solution shall not be returned to the supply bottle.

The solution in the beaker shall be brought to a temperature of approximately 65 deg. fahr. before the test is made by placing the beaker in a larger vessel containing water at the proper temperature and stirring with a glass thermometer.

Pieces of conduit about 6 in. long shall be used for the test, with the ends cut off approximately square, cooled before the test if heated by sawing. Each sample shall be washed in running water, dipped up and down in a vessel containing either carbon tetrachloride or ether and allowed to dry before being placed in the test beaker.

The sample thus prepared shall be stood on end in the copper-sulphate solution for 1 min., without moving or stirring the solution. At the end of 1 min. the sample is to be removed, rinsed in running water and wiped lightly, inside and outside, with white cheesecloth until dry. Violent rubbing and contact with the hand or any other object are to be avoided.

Interpretation of Test—The zinc coating of the sample is dissolved by the solution and a coating of copper deposited in its place. As long as zinc remains, the copper can be removed easily by washing and wiping,

TABLE 4—FLEXIBLE STEEL CONDUIT DIMENSIONS

Nominal Inside Diameter, in.	Actual Inside Diameter, in.[1]		Outside Diameter, in., Max.	Thickness of Strip, in., Min.	Approximate Net Weight per 100 Ft., lb.	Tension, lb., Min.	Radius for Bending, in., Min.
	Min.	Max.					
3/16	0.188	0.200	0.28	0.010	6.0	40	¾
¼	0.250	0.265	0.35	0.010	8.0	60	⅞
5/16	0.313	0.330	0.42	0.012	10.0	70	1
⅜	0.375	0.395	0.48	0.012	11.5	80	1¼
7/16	0.438	0.460	0.55	0.012	13.0	85	1⅜
½	0.500	0.525	0.62	0.014	16.0	90	1½
⅝	0.625	0.656	0.75	0.014	20.0	100	2
¾	0.750	0.790	0.92	0.016	25.0	120	2¼
⅞	0.875	0.920	1.03	0.016	33.0	125	2⅝
1	1.000	1.050	1.16	0.016	40.0	125	3
1¼	1.250	1.313	1.42	0.018	50.0	125	3½

[1]The limits specified in the table are those within which any make of conduit should be maintained and do not necessarily apply as the limits for any one piece of conduit.

Installation—To protect the electric wires from abrasion, and to prevent the conduit from unwinding, all exposed free ends, when installed, should be bushed with suitable ferrules soldered to the conduit. Where taps or joints are made, suitable junction-boxes shall be used, and also the ends of the conduit entering these boxes shall be carefully bushed with ferrules.

Specifications for Insuring Quality—To insure a product that will be suitable for the conditions ordinarily met in automobile wiring, flexible metallic conduit should conform to the following specifications:

(1) The conduit shall be such that a sample 3 ft. long will not open at any point when subjected for 1 min. to a tension test corresponding to the values given in Table 4

(2) The conduit must be such that it will not open when bent in a curve, the inner radius of which corresponds to the values given in Table 4

(3) The interior of the conduit shall be free from burrs or sharp edges that might cause abrasion of the insulation on the wire, and from obstructions that might interfere with the easy introduction of the maximum-size wire for which the conduit is normally suitable

Tests for Galvanizing—The copper-sulphate method is recommended for testing the galvanizing of flexible

but when the zinc has been entirely dissolved at any point the copper deposited at that point will not wash or wipe off. The number of dips required to cause a fixed copper deposit is, therefore, in some degree a measure of the thickness of the zinc coating.

A sample of flexible conduit shall pass this test if it does not have any of its fixed immersed surface covered with a fixed copper deposit after 1 min. of immersion, or more than 25 per cent of its immersed surface covered with a fixed copper deposit after a second immersion for 1 min. Several samples should be tested and a comparison noted.

Each sample shall be subjected to at least one additional dip, and the dips are generally continued until the entire immersed surface is coated with a fixed copper deposit.

Non-Metallic Conduit

(Proposed S.A.E. Recommended Practice)

The Electrical Equipment Division recommends for adoption as S.A.E. Recommended Practice the accompanying specification for non-metallic conduit for electrical wiring. This specification was formulated by the Subdivision on Flexible Conduit, together with the specification for flexible steel conduit, to fill the demand created by the extensive use of non-metallic conduit or "loom" in wiring cars for electrical apparatus. The two specifications were developed together and afford a definite basis for the purchasing and testing of these materials.

TABLE 5—NON-METALLIC FLEXIBLE CONDUIT DIMENSIONS

Nominal Inside Diameter, in.	Actual Inside Diameter,[2] in.		Outside Diameter, in., Max.	Approx. Weight, lb. per 100 Ft., lb.	Minimum Radius for Bending, in.	
	Min.	Max.			At 50 deg. Fahr.	At 70 deg. Fahr.
3/16	0.188	0.200	0.400	3.9	6	½
7/32	0.219	0.293	0.480	4.2	6	½
¼	0.313	0.335	0.530	4.5	6	½
⅜	0.375	0.450	0.725	6.1	6	½
½	0.500	0.565	0.875	8.3	6	½
⅝	0.625	0.736	0.975	10.2	..	..
¾	0.750	0.820	1.125	11.5	..	..
1	1.000	1.050	1.313	16.0	..	..
1¼	1.250	1.325	1.675	20.5	..	..

[2]The limits specified in this table are those within which any make of conduit should be maintained and do not necessarily apply to any one piece of conduit.

NON-METALLIC FLEXIBLE CONDUIT

General Information—Non-metallic flexible conduit is recommended for use as a mechanical protection to insulated wire that otherwise would be exposed to injury. Conduit shall be designated by the nominal inside-diameter.

Sizes and Dimensions—The sizes are listed in Table 5. The radius at which conduit can be bent without rupture depends on the temperature as well as on the wires enclosed in it at the time the bend test is made. Because of this the minimum radius for bending is given for conduit enclosing the largest wire for which it is suitable, and at two different temperatures. Conduit of greater than ½-in. nominal inside-diameter is ordinarily used for enclosing groups of wires that may vary in their makeup. It is, therefore, difficult to give definite radii for these sizes.

Installation—Conduit is treated with a moisture-repellant compound on the outside, but is not treated to withstand water on the inside. Therefore, when installed, the ends should be carefully sealed with friction tape, or other effective means to prevent the entrance of moisture.

As a further protection, a hole approximately ⅛ in. diameter should be burned with a hot iron in the bottom of the conduit at each pocket or low point, so that any moisture that may collect in the conduit will drain out.

Specifications for Insuring Quality—To insure a product that will be suitable for the conditions ordinarily met in automobile wiring, the conduit should conform to the following specifications. As a conduit is somewhat subject to aging, the tests should be made within 1 month of the date of manufacture.

(1) The design and construction of the conduit shall be such as to afford adequate mechanical protection to the wire. Its dimensions shall conform to Table 5 and all materials used must be electrically non-conducting

(2) Conduit that is made with a double wall shall be constructed so that the inner wall will not be removable in lengths of more than 3 ft.

(3) The conduit shall be free from obstructions that might cause abrasion of the insulation on the wire or interfere with the easy introduction of the maximum-size wire for which the conduit is normally suitable

(4) All sizes of conduit shall be capable of withstanding a tension test of 200 lb. for 5 min. without breaking or opening at any point. The elasticity of the conduit shall be such that 5 min. after the test-force has been removed, the elongation, measured between marks placed 20 in. apart on the sample before test, will not be more than 15 per cent

(5) Conduit in sizes up to and including ½-in. inside-diameter, when containing an insulated wire of the maximum diameter for which it is normally suitable, shall be capable of being bent without rupture to a radius of 6 in. when at a temperature of 50 deg. fahr., or to a radius of ½ in. when at a temperature of 70 deg. fahr.

(6) The conduit shall be capable of being flattened with a wooden mallet for a length of 6 in. in the center of a longer length, or by being trod on until the opposite walls are forced together, and of their being restored to roundness by working with the fingers so that a wire of maximum size for which it is normally suitable may be readily introduced. The compound must not crack open in this test

(7) The outer surface of the conduit shall be treated with a moisture-repellant compound. Test samples from 6 to 8 in. long, closed with corks, sealed by dipping in melted paraffin, immersed vertically in water at from 62 to 70 deg. fahr. for 24 hr. and then wiped dry with cloth or blotting paper, must not show an increase of more than 10 per cent in weight

(8) The conduit shall not convey fire, nor support combustion for more than 1 min. after five 15-sec. applications of a standard test-flame, with intervals of 15 sec. between applications. A standard test-flame is the blue flame, about 5 in. high, produced by a ½-in. Bunsen burner, fed with ordinary illuminating gas at normal pressure

(9) The compounds must not drip from the conduit when at a temperature not exceeding 160 deg. fahr.

ENGINE DIVISION REPORT

Carbureter Flanges

(Proposed Revision of S.A.E. Standard)

At the meeting of the Engine Division held last April a Subdivision was appointed to consider the consolidation of the present carbureter sizes in answer to requests that had been received by the Division. The elimination of one or two sizes was considered but deemed unwise. A proposal was then prepared by the Subdivision in which the flange dimensions of the $\frac{1}{2}$ and $\frac{5}{8}$-in. nominal-size carbureters and of the $\frac{3}{4}$ and $\frac{7}{8}$-in. sizes were the same. This was circularized among the carbureter and engine manufacturers for approval or suggestions. The replies received indicated general approval.

It is therefore recommended by the Engine Division that the flange dimensions for the $\frac{1}{2}$-in. nominal-size carbureter shall conform with the dimensions shown in the present standard, page A8, S.A.E. Handbook, for the $\frac{5}{8}$-in. size, and that the flange dimensions for the $\frac{3}{4}$-in. size shall be the same as for the $\frac{7}{8}$-in. nominal size. All of the nominal carbureter openings in the present standard are to be retained.

Engine Numbers

(Proposed Revision of S.A.E. Standard)

Three years ago a special committee of the Society was appointed to confer with a committee of the National Automobile Chamber of Commerce and representatives of the Underwriters Laboratories with a view to recommending some suitable means for locking automobiles so as to minimize theft. This committee was eventually continued to serve in a technical advisory capacity with the Insurance Committee of the National Automobile Chamber of Commerce and the Underwriters Laboratories with regard to a new method proposed by the latter of establishing insurance ratings for different makes of automobile, based on the hazards involved in various types of mechanical construction and the materials used. In the deliberations at joint meetings of the committees it was stated by the representatives of the Underwriters Laboratories that wherever S.A.E. Standards were considered suitable for the purpose, they would be included in the insurance-hazard schedule that was under study. Discussion of theft hazards led to consideration of methods of marking or numbering engines, frames and other major parts of automobiles so that the numbers could not be readily effaced or changed, but be readily visible for the purpose of inspection. The representatives of the Underwriters Laboratories expressed the view that the present S.A.E. Standard method of numbering does not give the desired protection, and it was requested that the possibilities of devising a system of numbering that would be more effective be studied. The subject was taken up in the Engine and the Frames Divisions and a general questionnaire sent to engine and automobile manufacturers, representatives of the insurance companies and a few metallurgists to secure comment on the numbering systems that had been suggested and to elicit further ideas. The majority of the replies indicated the use of and preference for plain figures about $\frac{1}{4}$ in. high deeply stamped into a pad or plain surface cast on the engine. Several suggestions were submitted, such as inserting an expanded disc in a counterbored hole in the crankcase, casting a special alloy in the engine crankcase on which the engine number might be stamped, casting numbers of an opaque material in the cylinder block in such a way that an X-ray photograph would show the numbers, using raised numbers, casting a small thin fin on which the numbers could be stamped on the crankcase so that the fin could be broken off by the dealer and held by the purchaser, and casting on a small thin brass plate with edges crimped down $\frac{1}{8}$ in. and knurled so as to anchor the edges securely in the crankcase. The suggested methods were considered by the Engine Division and the following revision of the present S.A.E. Standard, page A13, S.A.E. Handbook, was finally recommended. The method submitted is considered the simplest and most effective practical system for numbering engines that has been devised for protection against theft.

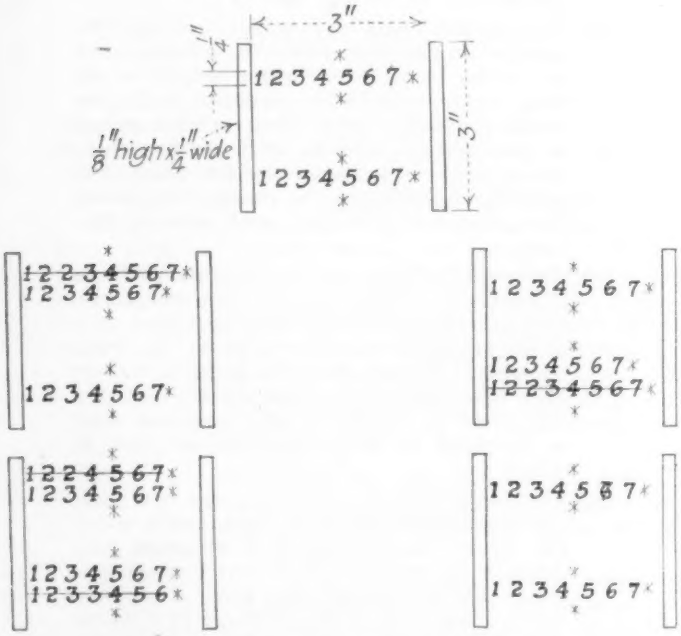


Fig. 1—Methods of Numbering Engines

The Arrangement in the Single View at the Top Is Correct and the Numbering in the Upper Pair of Drawings Is Acceptable, Only One Number Having Been Corrected in Each Case. The Lower Pair of Drawings Show Two Cases That Are Not Permissible; in the Drawing at the Left Both Numbers Have Been Corrected or Changed, While in the Other Drawing a Single Digit Has Been Corrected by Stamping a Second Digit over the Original One

> The engine serial or identification number shall be placed near the top of the right-hand side of the crankcase proper in a position in which it can be read easily. It shall be between two vertical ribs or beads $\frac{1}{4}$ in. wide, $\frac{1}{8}$ in. high, 3 in. long and 3 in. apart as shown in the single drawing at the top of Fig. 1. The surface of the casting between the ribs shall be left rough as cast and unpainted on the finished engine. The numbers shall be evenly stamped in the casting 1/32 in. deep and shall be $\frac{1}{4}$ in. high and of script form. The first digit shall be stamped close to the left-hand rib and the last digit shall be followed by a large star or other character to prevent adding digits. A star or other character also shall be stamped immediately above and below each number to prevent adding another number. The numbers shall be stamped twice on each casting, as illustrated, to permit correcting any errors made in stamping either number. No other number or character shall be placed within the space provided.
>
> If an error is made in stamping one number, it may be crossed out and the correct number stamped in immediately above or below as shown in the upper pair of drawings in Fig. 1. In no case shall both numbers be crossed out as shown in the lower left corner and new ones stamped, and more than three numbers must never appear, one wrong number crossed out and two correct numbers.

By this method, in case an error is made in stamping

either number, an additional number would be stamped directly under or above the number, the number stamped in error being cancelled by stamping a horizontal line through it. In this way two correct unmutilated numbers would appear on each engine. In case errors were made in stamping both the original numbers, the casting would be scrapped, as the system requires that at least one of the two original numbers be not mutilated in any way. The proposed method of numbering engines does not require additional skilled employes or tool equipment, but its adoption should be preceded by an educational campaign in the shops to impress the men who number the engines with the necessity for care and accuracy in doing the work. It has been suggested that a fine or other suitable penalty be imposed for carelessness or the spoiling of a certain percentage of castings by wrong numbering, but it is believed that by properly instructing the employes practically no errors would be made which would necessitate scrapping castings.

The other important reason for using a method of numbering engines that will make mutilation or changing of the numbers evident, is to obtain the 7½-per cent reduction in theft-insurance premiums that the underwriters state will be allowed. The arrangement under which the premium reductions may be had are

(1) If only the engine number or car-frame number conforms with the underwriters' requirements, a reduction of 7½ per cent in the theft-insurance premium will be allowed
(2) If both the engine and frame numbers conform with such requirements, a reduction of 20 per cent in the premium will be allowed

Work is under way in the Frames and Passenger Car Divisions with the object of formulating another method of numbering car frames than the present standard, page K41, S.A.E. HANDBOOK, to make available the 20-per cent reduction in insurance premiums as soon as possible, but the numbering of frames involves difficulties not encountered in numbering engines.

FAN BELTS AND PULLEYS

(Proposed Revision of S.A.E. Recommended Practice)

The present standard for fan belts and pulleys, page A14, S.A.E. HANDBOOK, which was adopted by the Society in 1915, includes only flat belt and pulley widths. The development of better fan and fan-drive mechanisms required for the more efficiently cooled modern engines has led the Engine Division to revise and extend the standard. A Subdivision was appointed to prepare the proposed specification which includes flat and V-belts and pulleys and fan-pulley spindles for solid and adjustable fan-brackets. Criticisms of the Subdivision's proposal were considered by the Engine Division which now presents the recommendation embodied in Figs. 2 to 6 and Tables 6 to 12 inclusive.

TABLE 6—FLAT FAN-BELT AND PULLEY DIMENSIONS

Belt Width,[3] in.	Pulley Width,[4] in.	Maximum Fan Diameter, in.	Maximum Projected Blade Width, in.
1	1⅛	Up to 14	1⅝ Inclusive
1¼	1⅜	15 to 18	1⅞ Inclusive
1½	1¾	19 to 20	2 Inclusive
2	2¼	20 to 22	2¼ Inclusive
2½	2¾	21 to 24	2½ Inclusive
3	3¼	25 to 26	2½ Inclusive

[3] The widths given are subject to a variation of ±1/32 in.
[4] The widths given are subject to a variation of ±0.01 in.

TABLE 7—V-FAN BELT AND PULLEY DIMENSIONS

Width of V-Belt at Top, in.	Minimum Depth of Groove Below Bottom of Belt, in.	Maximum Fan Diameter, in.	Maximum Projected Blade Width, in.
⅝	⅛	Up to 14	1⅝ Inclusive
⅝	⅛	15 to 18	1⅞ Inclusive
¾	3/16	19 to 20	2¼ Inclusive
1	3/16	21 to 22	2½ Inclusive
1¼	5/16	23 to 26	2½ Inclusive

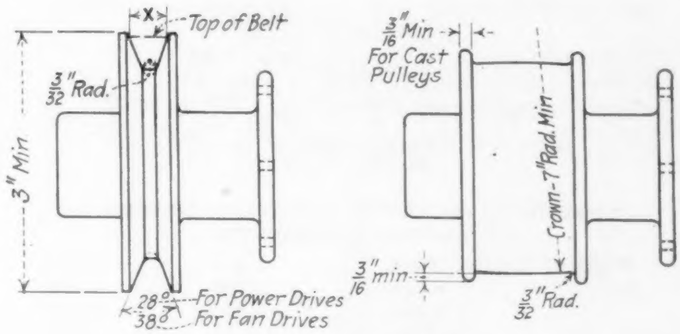


FIG. 2—TWO TYPES OF FAN PULLEYS
That Illustrated at the Left Is for a V-Belt and That at the Right for the Flat Type of Belt

TABLE 8—FAN-PULLEY DIMENSIONS

Ratio of Fan Driving Pulley to Engine Speed	Minimum Fan-Driving Pulley Diameter, in.	Minimum Fan-Driven Pulley Diameter, in.[5]
½	7½	3
1	5	3
1½	3	3

[5] Diameter to increase by ¼-in. increments.

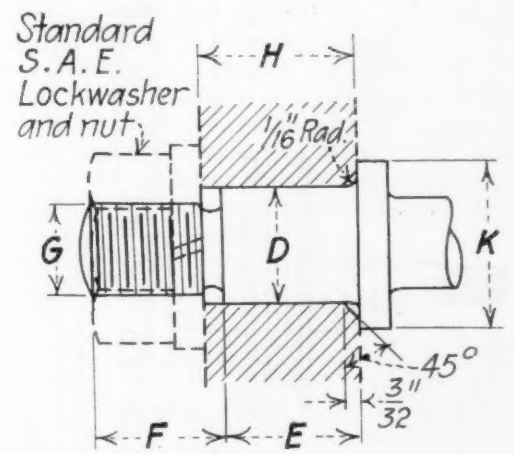


FIG. 3—FAN PULLEY SPINDLE FOR USE WITH SOLID BRACKETS

TABLE 9—DIMENSIONS OF FAN-PULLEY SPINDLE FOR SOLID FAN-BRACKETS

Width of Belt, in.	*D*	*E*	*F*	*G*	*H*	*K*
1-1¼	0.748 0.746	⅞	⅞	⅝-18	1	1
1½	0.873 0.871	1	⅞	⅝-18	1⅛	1⅛
2	0.998 0.996	1⅜	15/16	¾-16	1⅝	1¼
2½-3	1.248 1.246	1 9/16	1 5/16	1-14	2	1½

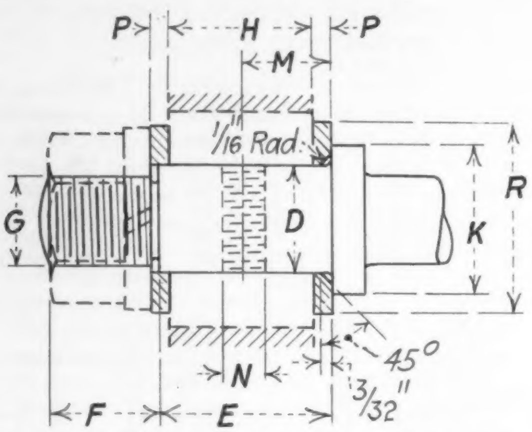


FIG. 4—FAN-PULLEY SPINDLES FOR USE WITH SLOTTED BRACKETS

TABLE 10—DIMENSIONS OF FAN-PULLEY SPINDLES FOR SLOTTED FAN-BRACKETS

Width of Belt, in.	1-1¼	1½-2	2½-3
D	0.748	0.998	1.248
	0.746	0.996	1.246
E	1 3/16	1 9/16	1⅞
F	13/16	15/16	1¼
G	⅝-18	¾-16	1-14
H	1	1⅛	1½
K	1	1¼	1½
M	⅝	13/16	1
N	5/16-18	½-13	½-13
P	⅛	¼	¼
R	1⅜	1¾	2

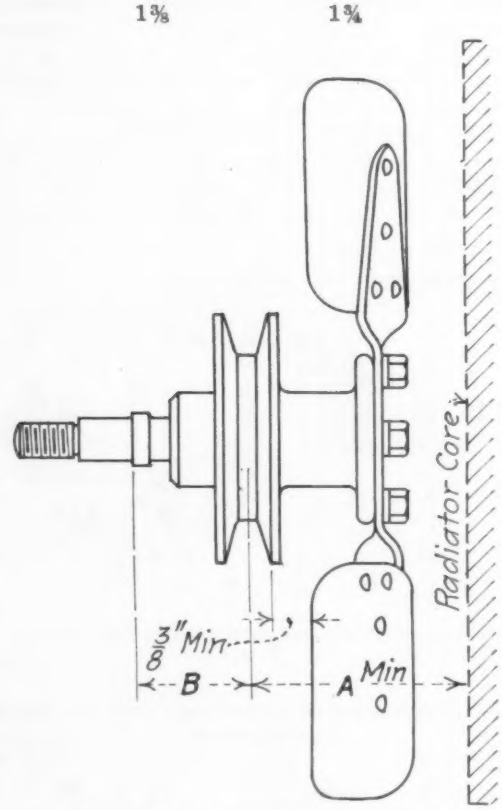


FIG. 5—FAN ASSEMBLIES FOR V-BELTS

TABLE 11—FAN-ASSEMBLY DIMENSIONS FOR V-BELTS

Belt Widths, in.	*A*	*B*
⅝	3⅛	1½
¾	3½	1¾
1	4	2⅛
1¼	4	2⅛

The different characteristics of the several types of V-belt have been considered and as many data included in the recommendation as is considered feasible. The details of the pulleys, spindles, fan blades and general location of the assemblies with respect to the radiator core have been checked against present practice and it is believed that general adoption of the recommendation will provide for much more efficient fan installations at reduced cost to the engine builders.

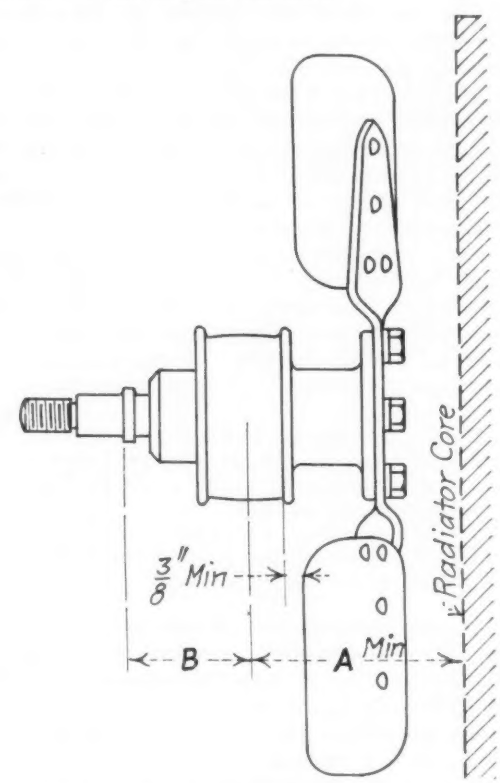


FIG. 6—FAN ASSEMBLIES FOR FLAT BELTS

TABLE 12—FAN-ASSEMBLY DIMENSIONS FOR FLAT BELTS

Belt Widths, in.	*A*	*B*
1	3¾	1¾
1¼	3¾	1¾
1½	3¾	1¾
2	4¼	2
2½	4¾	2½
3	4¾	2½

Angle of Groove—The included angle of the sides of rubber V-belts shall be 32 deg. for power-drive belts, and 42 deg. for fan-drive belts. This allows for the bulging of the inside of the belts when laid around pulleys.

Width of Groove—The width of the pulley groove measured at the outside diameter of the pulley shall clear the maximum width of the belt. For link belts, the next larger size pulley should be used.

ENGINE TESTING FORMS

(Proposed Revision of S.A.E. Standard)

For some time the Engine Division has been studying the possibility of extending the present S.A.E. Standard for Engine Testing Forms, page A16, S.A.E. HANDBOOK, to provide for the recording of data on testing internal-combustion engines of other than the automobile type, such as heavy stationary and farm lighting-plant engines, but it has been found impracticable to do so. The Sub-division submitted a tentative recommendation to the

Engine Division, however, proposing the adoption of the following changes in the present testing forms which have been approved by the Division.

Specification Sheet B

Under Item No. 6, Cooling System, provide for recording the fan diameter, projected width of fan-blades and the ratio of fan speed to engine speed.

Under Item No. 32, Lubricating System, Type and Description, provide for recording the Saybolt viscosity at Cold Test, 150 deg. fahr. and 350 deg. fahr.

Add a section entitled Accessories containing Item 33, Accessories Attached during Test, under which are to be listed the accessories attached to the engine during the test and conditions under which they operated.

Log Sheet C

Add a note to the effect that it is recommended that results be corrected to a temperature of 60 deg. fahr. and 29.92 in. of mercury barometric pressure by using the formula

$$\text{B. Hp.}_c = [\text{B. Hp}_o \times P_s] \div [P_o \sqrt{(T_o/T_s)}]$$

where

B. Hp_c = corrected brake horsepower

B. Hp_o = observed brake horsepower of mercury

P_o = observed barometric pressure in inches of mercury

P_s = standard barometric pressure in inches of mercury

T_o = observed absolute temperature in degrees fahrenheit

T_s = standard absolute temperature in degrees fahrenheit

Curve Sheet D

Change the ordinates for the fuel consumption from "0.5 to 2.5" to "0.5 to 1.5" lb. per b.hp-hr. so that four ordinate lines will represent 0.1 lb. per b.hp-hr.

Insert the intermediate values for the brake horsepower ordinates.

Mufflers

(Proposed S.A.E. Recommended Practice)

Last year the Engine Division prepared a recommendation principally with regard to the mounting of mufflers, but it was felt that this subject should be thoroughly investigated before a standard, if recommended at all, should be adopted. A Subdivision was appointed and a mass of data on existing practice obtained with the intention of, if possible, arranging a series of muffler sizes in accord with a definite range of engine displacements. These data showed a total lack of uniformity of muffler capacity with regard to piston displacement and it was therefore decided to consider the subject from the point of view of muffler sizes in general use. The Subdivision prepared a report that was submitted to engine manufacturers and their replies were considered by the Engine Division. After careful study of the report and the generally favorable comments with regard to its adoption, the Engine Division has approved the accompanying proposal for adoption as S.A.E. Recommended Practice. The proposal is limited to nine sizes given in Table 13 that circularization indicates are most popular and are considered adequate for all general applications. The exhaust-tubing and tail-pipe sizes proposed were selected as being suitable for the usual range of engine sizes, and are identical for all mufflers of the same diameter. As many mufflers are built up of sections, they can be obtained in a variety of lengths, but with standard heads. The lengths proposed are those in most general use and permit the use of a width of stock for the one-piece type that is readily procurable from the steel mills.

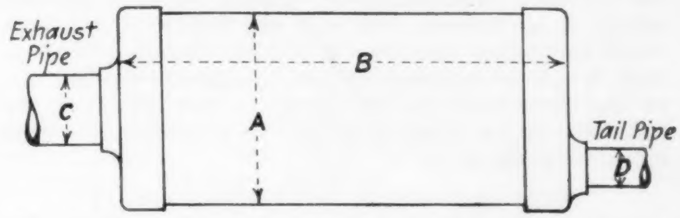


FIG. 7—PROPOSED RECOMMENDED PRACTICE FOR ENGINE MUFFLERS

TABLE 13—RECOMMENDED STANDARD SERIES OF MUFFLERS

No.	*A* Diameter, in.	*B* Length, in.	Muffler Volume, cu. in.	*C* Exhaust-Pipe Tube-Diameter, in.	*D* Tail-Pipe Tube-Diameter, in.
1	5	20	390	2	1½
2	5	24	470	2	1½
3	5	28	550	2	1½
4	6	20	565	2½	1¾
5	6	24	680	2½	1¾
6	6	28	790	2½	1¾
7	7	20	770	3	2
8	7	24	925	3	2
9	7	28	1,008	3	2

It is recommended that the length of the exhaust-pipe tubing shall not be less than 5 ft. from the exhaust-manifold to the muffler.

It is the intention of the Division to standardize muffler mountings after the present proposal has become effective, provided such standardization seems desirable.

FRAMES DIVISION REPORT

Running-Board Brackets

(Proposed S.A.E. Recommended Practice)

The Frames Division recommends for adoption as S.A.E. Recommended Practice the passenger-car running-board brackets shown in Fig. 8. Running-board or step brackets in present-day use are in general similar, but the elimination by standardization of variations such as those in the number, size and location of the rivet-holes and the radius of the curve will make it possible to obtain interchangeable brackets more easily and permit savings

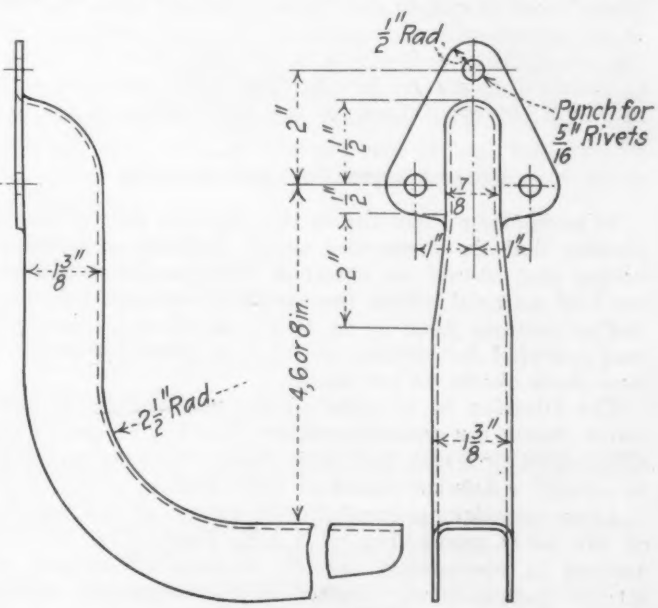


FIG. 8—STEP-BRACKET

in tools and in the time required for punching or drilling the frames. Three heights of bracket are recommended, which, it is believed, will suit any height of running-board by proper selection. If further variation is necessary, it can be obtained by shifting slightly the position of the rivet-holes in the frame. The width of the brackets can be changed readily to suit various widths of running-board.

IRON AND STEEL DIVISION REPORT

Iron and Steel Specifications

(Proposed Revision of S. A. E. Standards)

Realizing the need of bringing the S.A.E. Steel specifications and the notes that accompany them uptodate, so as to reflect current metallurgical practice; also the need for physical-property charts covering all of the S.A.E. Steels, the Iron and Steel Division undertook about 2 years ago a thorough revision of the S.A.E. Steel Specifications and the notes referring to them.

Owing to the advantage they had obtained in the past from the work of the Society by the standardization of steel specifications, the automobile and parts manufacturers and the steel producers all extended their hearty and active cooperation in this work. In addition to the representatives of these interests, the personnel of the Division was supplemented by representatives from the Ordnance Department and the engineering division of the Air Service; also by representatives of corresponding committees of the American Gear Manufacturers' Association and of the American Society for Testing Materials.

The specifications covering the chemical compositions were all reconsidered and certain little-used compositions deleted. Minor revisions were made in a number of other compositions and additions to the list of standard steels were made in response to requests from other engineering organizations which had adopted S.A.E. Steels for their needs, particularly the metallurgical committee of the American Gear Manufacturers' Association.

The Division also undertook to collect and tabulate data obtained from users of S.A.E. Steels on the physical properties of the various compositions after heat-treatment in accordance with the recommendations of the Society. The statistical data thus obtained were transferred to graphs and further checked by actual tests in the laboratories of some of the Division members, with the result that the Division is now able to submit charts of physical properties for the 3200, 3300 and 3400 series of S.A.E. Steels. Work on the 6100 series is not complete.

Conservative Values Indicated

In presenting these charts the Division desires to emphasize that the properties shown indicate conservative values that should be obtained with proper heat-treatment of material within the ranges of composition specified *on sections from ½ in. to 1½ in. diameter or thickness* and that *for sections over 1½ in. diameter or thickness these charts do not apply.*

The Division is working on the preparation of additional charts for sections greater than 1½ in. and, while substantial progress has been made, it is not prepared to submit a definite report at this time.

After considering carefully the extent of the revision of the notes pertaining to S.A.E. Steels, the Division decided to recommend specific temperature-ranges for specific compositions, instead of following the former method of general treatments applying to several steels, thereby permitting of the application of narrower temperature-ranges in each heat-treatment.

In order that there might be no confusion in connection with such shop drawings as are in circulation and which carry the former heat-treatment symbols, it was decided to adopt Roman numerals for the revised heat-treatments, in lieu of the alphabetical symbols that have heretofore been used. These Roman numerals are placed after the steel specification number, thereby indicating at a glance the specific composition of steel and its heat-treatment.

Specific Heat-Treatments

Further study revealed that eight types of heat-treatment will cover general commercial applications. Five of these treatments apply to case-hardening practice and the other three are so-called toughening or hardening treatments. All the treatments recommended are intended to reflect the best metallurgical practice. It is appreciated, however, that there are instances where treatments that are satisfactory have been developed by some manufacturers which will vary from those recommended by the Division. It has been the aim of the Division to recommend only such treatments as will develop safely the characteristic physical properties of each steel. It is possible that in certain instances a manufacturer will be confronted with particular conditions wherein the recommended treatment for a given steel will not apply in every detail. In such instances, the specific treatment must be determined by careful study and balancing of local conditions.

The types of heat-treatments recommended are as follows:

Heat-Treatment I—Carburize, quench from box and draw

Heat-Treatment II—Carburize, quench from box; reheat once to refine the case, quench and draw

Heat-Treatment III—Carburize, quench from box; reheat twice and quench twice, to refine the core and harden the case respectively, and draw

Heat-Treatment IV—Carburize, cool in box; reheat once to refine the case, quench and draw

Heat-Treatment V—Carburize, cool in box; reheat and quench twice, to refine the core and harden the case respectively, and draw

Heat-Treatment VI — Heat, quench and draw. A toughening or hardening treatment for parts machined from bar stock that are to be heat-treated either before or after machining

Heat-Treatment VII—Normalize, reheat, quench and draw. A toughening or hardening treatment for forged parts, usually applied before machining

Heat-Treatment VIII—Normalize, anneal, machine, reheat, quench and draw. A treatment for parts made from steels requiring a normalizing and annealing treatment prior to machining and final treatment. Particularly essential for forged parts of the higher alloy compositions. This treatment is particularly adapted to oil-hardening gear steel

The Iron and Steel Division has continued the use of the S.A.E. system of code numbers for identifying the grades and types of steel. Although this system may not describe perfectly the detailed composition of each steel, it has been adopted generally throughout the steel trade; in addition, it has been extended by individual firms to designate many grades of steel not actually included in the S.A.E. specifications.

While it is realized by the Division that the present system using four or five digits does not indicate precisely all the alloying elements and their percentages, it

is a system that has served well in the past and the limit of its applications has not yet been reached. At various times other systems of symbols have been suggested, all of them based on the present successful S.A.E. system, in which complicating symbols, such as letters and various combinations of numbers, have been employed. Entirely aside from the fact that the present S.A.E. numbers are established and identified on hundreds of thousands of blueprints and specification sheets, the proposed changes have not been able to withstand the light of extensive criticism, due to the fact that their disadvantages have outweighed their apparent advantages.

There is a Subdivision of the Iron and Steel Division whose duty it is to make an extensive study of this phase of the work, and it has given and it will give careful consideration to any suggestions that have been or may be offered looking toward the improvement and extension of the present code.

Application of Data

The complete data regarding each grade of steel, such as the code number, the composition, certain notes descriptive of the steel, and the heat-treatments that will apply for such composition and charts showing the physical properties that may be developed by the recommended heat-treatments, will probably appear on the same page or on opposing pages of the final report and of the data sheets. The engineer will then have assembled before him complete data for each particular grade of steel. He can compare them easily and choose the one that will apply best to his particular purpose. For example, if it is desired to use a steel for certain structural parts that require a yield-point of 90,000 to 100,000 lb. per sq. in., and an elongation in 2 in. of about 18 per cent, it will be found upon reference to the various charts that there are several types or compositions that will provide the desired physical properties. With this array of available material before him, the engineer, production manager or metallurgist is in a position to make a choice, after taking into consideration such important factors as ease of machinability, resistance to shock and fatigue, penetration of hardening effect, ease of heat-treating, availability and price.

Economic Advantages

The standardization work of the Iron and Steel Division has cultivated widespread use of the S.A.E. Steel Specifications as a common language between the user and the producer of low and medium carbon ranges of plain-carbon and alloy-steels suitable for a great variety of applications; and the economic benefits resulting from the use of the S.A.E. Steels have been so evident and so clearly defined in the manufacturing world that they have been adopted generally in industries other than those in the automotive field. This very extensive use of S.A.E. Steels is reflected in the great number of inquiries received by the Society for the reports of the Division. These requests come from all branches of the metal trades in nearly every State in the Union, as well as from foreign countries. The demand from the small manufacturers for the reports of the Division is particularly noticeable and the form of their requests indicates that they find the specifications for S.A.E. Steels of great value. As stated by K. W. Zimmerschied, a former chairman of the Iron and Steel Division, "The specifications are intended to provide a good commercial quality of steel, leaving the ultra refinements to those whose problems or conditions require such special treatment." The outstanding fact is that the use of heat-treated carbon and alloy-steels has contributed largely to the phenomenal success of the automotive industry, and the S.A.E. Steel Specifications have standardized them for consumers and producers alike.

Acknowledgment is made of the cooperation and valuable information furnished to the members of the Iron and Steel Division by the following non-members who, among others, have assisted materially in preparing the revised report and discussing the many phases of the work at the Division's meetings.

S. P. Rockwell	American Gear Manufacturers Association
John Miller	Pierce-Arrow Motor Car Co.
J. H. G. Williams	Billings & Spencer Co.
M. H. Schmid	United Alloy Steel Co.
M. P. Rumney	Detroit Steel Products Co.
E. J. Janitzky	Illinois Steel Co.
M. T. Lothrop	Timken Roller Bearing Co.
H. T. Chandler	C. Harold Wills Co.
V. A. Crosby	Recently with Packard Motor Car Co.
A. H. Miller	Midvale Steel & Ordnance Co.

Part I—Introduction

The steel compositions included in this report are considered adequate for practically all parts made of ferrous materials that are necessary for the production of automotive apparatus, and include grades that have been found commercially available and technically adequate for the service required of such parts. In cases where very special requirements or exceptional quality make it necessary, grades containing less phosphorus and sulphur and narrower ranges of carbon and manganese are available, but such steels should be obtained by special arrangement between the mill and the purchaser.

SPECIFICATION NUMBERS

A numeral index system is used for the specifications contained in this report, which makes it possible to use specification numerals on shop drawings and blueprints that are partially descriptive of the quality of material covered by such numbers. The first figure indicates the class to which the steel belongs: thus "1—" indicates a carbon steel; "2—" a nickel steel and "3—" a nickel-chromium steel. In the case of the alloy steels, the second figure generally indicates the approximate percentage of the predominant alloying element. Usually the last two or three figures indicate the average carbon-content in "points," or hundredths of 1 per cent. Thus 2340 indicates a nickel steel of approximately 3 per cent nickel, 3.25 to 3.75, and 0.40 per cent carbon, 0.35 to 0.45; and 71360 indicates a tungsten steel of about 13 per cent tungsten, 12 to 15, and 0.60 per cent carbon, 0.50 to 0.70. The basic numerals for the various qualities of steels specified are

Carbon steels	1
Nickel steels	2
Nickel-chromium steels	3
Molybdenum steels	4[a]
Chromium steels	5
Chromium-vanadium steels	6
Tungsten steels	7
Silico-manganese steels	9

[a]This numeral has been agreed upon as the index to the Molybdenum group but no specific compositions have as yet been recommended by the Iron and Steel Division.

REGARDING SPECIFICATIONS AND NOTES ON HEAT-TREATMENTS AND PHYSICAL PROPERTIES

The Notes on heat-treatments and physical properties are not to be considered in any way a part of the stand-

ard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

S.A.E. Steels should be purchased on the basis of requirements as to chemical composition, and the specifications provided herein should be used in the purchase of the grades and types of steel covered by each. Requirements as to physical properties have been omitted for all steels except steel castings because the majority of steels for automotive purposes are either worked or given special heat-treatments by the purchaser.

Part II—Specifications for Automotive Steels

(Proposed Revision of S.A.E. Standard)

Manufacture

Process

The steel shall be made by the Bessemer, open-hearth, crucible, electric, or any other process approved by the purchaser.

Discard

A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Chemical Properties

The steel shall conform to the specified requirements as to chemical composition.

Ladle Analysis

An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified. This analysis shall be made from drillings taken at least ¼ in. beneath the surface of a test ingot obtained during the pouring of the melt, and in as sound metal as possible. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified.

Check Analysis

Analyses may be made by the purchaser. The chemical composition thus determined shall conform to the requirements specified.

Drillings for analyses of bars, billets or other regular shapes shall be taken parallel to the axis, at any point midway between the center and the surface.

Drillings or cuttings for analyses of irregularly shaped pieces shall be taken from both the thickest and the thinnest sections. Surface drillings shall be discarded.

Wire, tubing, sheets, and rods less than 1¼ in. thick shall be sampled through or across the entire section.

Finish

Defects

The material shall be free from injurious defects and shall have a workmanlike finish.

Inspection and Rejection

Inspection

The inspector representing the purchaser shall have free entry at all times to all parts of the manufacturer's works that concern the manufacture of the material ordered while work on the contract of the purchaser is being performed. The manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

The purchaser may make the tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejections

Unless otherwise specified, any rejection based on tests made by the purchaser in its own laboratory shall be reported within 10 working days from the receipt of samples.

Material which shows injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Rejection Tests

Samples tested by the purchaser in its own laboratory that represent rejected material, shall be preserved for one month from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

Part III—Chemical Composition[6]

(Proposed Revision of S.A.E. Standard)

CARBON STEELS

S. A. E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.
1010	0.05–0.15	0.30–0.60	0.045	0.05
1015	*0.10–0.20*	*0.30–0.60*	*0.045*	*0.05*
1020	0.15–0.25	0.30–0.60	0.045	0.05
1025	0.20–0.30	0.50–0.80	0.045	0.05
1030	*0.25–0.35*	*0.50–0.80*	*0.045*	*0.05*
1035	0.30–0.40	0.50–0.80	0.045	0.05
1040	*0.35–0.45*	*0.50–0.80*	*0.045*	*0.05*
1045	0.40–0.50	0.50–0.80	0.045	0.05
1046	*0.40–0.50*	*0.30–0.50*	*0.045*	*0.05*
1050	*0.45–0.55*	*0.50–0.80*	*0.045*	*0.05*
1095	0.90–1.05	0.25–0.50	0.040	0.05

SCREW STOCKS

S. A. E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Range
1112	0.08–0.16	0.60–0.80	0.09–0.13	0.075–0.15
1120	0.15–0.25	0.60–0.90	.... 0.06	0.075–0.15

STEEL CASTINGS[7]

S. A. E. No.	Carbon	Phosphorus Max.	Sulphur Max.
1235	As required by physical properties	0.05	0.05

NICKEL STEELS

S. A. E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Nickel Range
2315	0.10–0.20	*0.30–0.60*	0.04	0.045	3.25–3.75
2320	0.15–0.25	0.50–0.80	0.04	0.045	3.25–3.75
2330	0.25–0.35	0.50–0.80	0.04	0.045	3.25–3.75
2335	0.30–0.40	0.50–0.80	0.04	0.045	3.25–3.75
2340	0.35–0.45	0.50–0.80	0.04	0.045	3.25–3.75
2345	0.40–0.50	0.50–0.80	0.04	0.045	3.25–3.75
2350	*0.45–0.55*	*0.50–0.80*	*0.04*	*0.045*	*3.25–3.75*
2512	max. 0.17	0.30–0.60	0.04	0.045	4.50–5.25

[6] The S.A.E. numbers in italics are proposed additions to the present list of standard compositions. Where a portion of the composition is set in italics a change from the present composition is indicated.

[7] See specification for steel castings.

NICKEL-CHROMIUM STEELS

S.A.E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Nickel Range	Chromium Range
3115	0.10-0.20	0.30-0.60	0.04	0.040	1.00-1.50	0.45-0.75
3120	0.15-0.25	0.30-0.60	0.04	0.045	1.00-1.50	0.45-0.75
3125	0.20-0.30	0.50-0.80	0.04	0.045	1.00-1.50	0.45-0.75
3130	0.25-0.35	0.50-0.80	0.04	0.045	1.00-1.50	0.45-0.75
3135	0.30-0.40	0.50-0.80	0.04	0.045	1.00-1.50	0.45-0.75
3140	0.35-0.45	0.50-0.80	0.04	0.045	1.00-1.50	0.45-0.75
3215	0.10-0.20	0.30-0.60	0.04	0.040	1.50-2.00	0.90-1.25
3220	0.15-0.25	0.30-0.60	0.04	0.040	1.50-2.00	0.90-1.25
3230	0.25-0.35	0.30-0.60	0.04	0.040	1.50-2.00	0.90-1.25
3240	0.35-0.45	0.30-0.60	0.04	0.040	1.50-2.00	0.90-1.25
3245	0.40-0.50	0.30-0.60	0.04	0.040	1.50-2.00	0.90-1.25
3250	0.45-0.55	0.30-0.60	0.04	0.040	1.50-2.00	0.90-1.25
3312	max. 0.17	0.30-0.60	0.04	0.040	3.25-3.75	1.25-1.75
3325	0.20-0.30	0.30-0.60	0.04	0.040	3.25-3.75	1.25-1.75
3335	0.30-0.40	0.30-0.60	0.04	0.040	3.25-3.75	1.25-1.75
3340	0.35-0.45	0.30-0.60	0.04	0.040	3.25-3.75	1.25-1.75
3415	0.10-0.20	0.45-0.75	0.04	0.040	2.75-3.25	0.60-0.95
3435	0.30-0.40	0.45-0.75	0.04	0.040	2.75-3.25	0.60-0.95
3450	0.45-0.55	0.45-0.75	0.04	0.040	2.75-3.25	0.60-0.95

CHROMIUM STEELS[8]

S. A. E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Chromium Range
5120	0.15-0.25	0.30-0.60	0.04	0.045	0.60-0.90
5140	0.35-0.45	0.50-0.80	0.04	0.045	0.80-1.10
5150	0.45-0.55	0.50-0.80	0.04	0.045	0.80-1.10
52100	0.95-1.10	0.20-0.50	0.03	0.030	1.20-1.50

CHROMIUM-VANADIUM STEELS

S. A. E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Chromium Range	Vanadium	
						Min.	Desired
6120	0.15-0.25	0.50-0.80	0.04	0.04	0.80-1.10	0.15	0.18
6125	0.20-0.30	0.50-0.80	0.04	0.04	0.80-1.10	0.15	0.18
6130	0.25-0.35	0.50-0.80	0.04	0.04	0.80-1.10	0.15	0.18
6135	0.30-0.40	0.50-0.80	0.04	0.04	0.80-1.10	0.15	0.18
6140	0.35-0.45	0.50-0.80	0.04	0.04	0.80-1.10	0.15	0.18
6145	0.40-0.50	0.50-0.80	0.04	0.04	0.80-1.10	0.15	0.18
6150	0.45-0.55	0.50-0.80	0.04	0.04	0.80-1.10	0.15	0.18
6195	0.90-1.05	0.20-0.45	0.03	0.03	0.80-1.10	0.15	0.18

TUNGSTEN STEELS

S. A. E. No.	Carbon Range	Manganese Max.	Phosphorus Max.	Sulphur Max.	Chromium Range	Tungsten Range
71360	0.50-0.70	0.30	0.035	0.035	3.00-4.00	12.00-15.00
71660	0.50-0.70	0.30	0.035	0.035	3.00-4.00	15.00-18.00
7260	0.50-0.70	0.30	0.035	0.035	0.50-1.00	1.50-2.00

SILICO-MANGANESE STEELS

S. A. E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Silicon Range
9250	0.45-0.55	0.60-0.90	0.045	0.045	1.80-2.20
9260	0.55-0.65	0.60-0.90	0.045	0.045	1.80-2.20

Part IV—Steel Castings[9]

S.A.E. SPECIFICATION 1235

(Proposed Revision of S.A.E. Standard)

Manufacture

Process

The steel may be made by any process approved by the purchaser. Three grades are recognized: hard, medium and soft.

Cooling

All castings shall be allowed to become cold. They shall then be reheated uniformly to the proper temperature to refine the grain, and allowed to cool uniformly and slowly.

Chemical Composition and Tests

Analysis

The castings supplied shall conform to the following chemical requirements in percentage on check analysis:

Carbon	As Required for Physical Properties
Phosphorus, not to exceed	0.05
Sulphur, not to exceed	0.05

Drillings

Drillings for analysis shall be so taken as to represent the average composition of the casting.

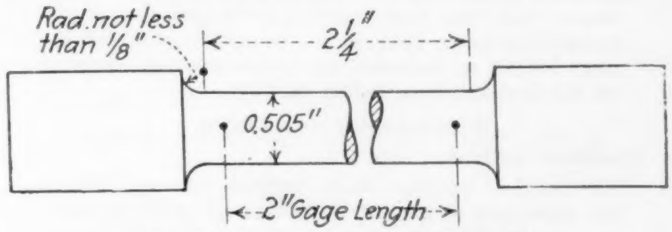


Fig. 9—Round Tension Test-Specimen

Physical Properties and Tests

Tensile-Test

The tensile properties of finished castings shall conform to the following minimum requirements:

	Hard	Medium	Soft
Tensile-Strength, lb. per sq. in.	80,000	70,000	60,000
Yield-Point, lb. per sq. in.	36,000	31,500	27,000
Reduction of Area, per cent	20.0	25.0	30.0
Elongation in 2 In., per cent	15.0	18.0	22.0

Bend Test

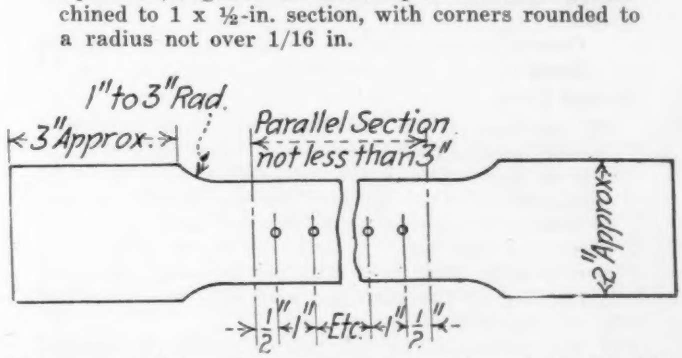
The test-specimens for soft castings shall bend cold through 120 deg., and for medium castings through 90 deg., around a 1-in. diameter pin without cracking on the outside. Hard castings shall not be subject to bend-test requirements.

Test to Destruction

For small or unimportant castings, a test to destruction on three castings from a lot may be substituted for the tension and bend tests. This test shall show the material to be ductile, free from injurious defects and suitable for the purpose intended. A lot shall consist of all castings from one melt in the same annealing charge. In case test-bars are cast separately, they shall be annealed with the lot they represent. The method of casting such test-bars, or casting test-bars attached to castings, shall be agreed upon by purchaser and manufacturer.

Tension Test

Tension test-specimens shall be machined to conform to the S.A.E. Standard Round Tension Test-Specimen, Fig. 9, and S.A.E. Standard Flat Tension Test-Specimen, Fig. 10. Bend test-specimens shall be machined to 1 x ½-in. section, with corners rounded to a radius not over 1/16 in.



The minimum distance between the outer punch marks shall be 2 in.

Fig. 10—Flat Tension Test-Specimen

Number of Tests

One tension and one bend test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension and one bend test shall be made from each melt.

[8] Steel 5165 has been omitted.

[9] This specification is substantially the same as Specification No. A27-14 of the American Society for Testing Materials.

Defective Test-Specimens

If any test-specimen shows defective machining or develops flaws it may be discarded, in which case another test-specimen may be selected by the manufacturer and the purchaser.

Retests

A retest shall be allowed if the percentage of elongation is less than that specified or if any part of the fracture is more than ¾ in. from the center of the gage length as indicated by scribe scratches marked on the test-specimen before testing.

WORKMANSHIP AND FINISH

Finished Castings

The finished castings shall conform substantially to the sizes and shapes of the patterns, shall be made in a workmanlike manner and be free from injurious defects.

MARKING OF CASTINGS

Marking Castings

The manufacturer's identification mark and the pattern numbers assigned by the purchasers shall be cast on all castings of sufficient size, in such positions that they will not interfere with the service of the castings.

INSPECTION AND REJECTION

Defective Castings

Minor defects that do not impair the strength of the castings may, with the approval of the purchaser, be welded by an approved process. The defects shall first be cleaned out to solid metal and after welding the castings shall be annealed.

Hidden Defects

Castings offered for inspection shall not be painted or covered with any substance that will hide defects, nor rusted to such an extent as to hide defects.

Part V—Malleable Iron Castings[10]

(*S.A.E. Standard*)

MANUFACTURE

Material

These specifications cover malleable iron castings for general automotive purposes.

Process

The castings shall be produced by either the air-furnace, open-hearth or electric-furnace process.

PHYSICAL PROPERTIES AND TESTS

Tensile-Test

The tensile properties of the test-specimens specified shall conform to the following minimum requirements:

Tensile-Strength, lb. per sq. in.	45,000
Elongation in 2 In., per cent	7.5

Special Tests

All castings, if of sufficient size, shall have cast thereon test-lugs of a size proportional to the thickness of the casting, but not exceeding ⅝ x ¾ in. in cross-section. On castings that are 24 in. or over in length, a test-lug shall be cast near each end. These test-lugs shall be attached to the casting at such a point that they will not interfere with the assembling of the castings, and may be broken off by the inspector.

If the purchaser or his representative so desires, a casting may be tested to destruction. Such a casting shall show good, tough malleable iron.

Tension Test-Specimens[11]

Tension test-specimens shall conform to S.A.E. Standard Tension Test-Specimen, Fig. 11. Test-specimens whose mean diameter at the smallest section is less than 19/32 in. will not be accepted for test.

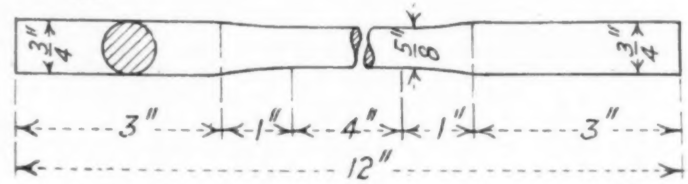


FIG. 11—MALLEABLE IRON TENSION TEST-SPECIMEN

Number of Test-Specimens

A set of three tension test-specimens shall be cast from each melt, without chills, using heavy risers of sufficient height to secure sound bars. The specimens shall be suitably marked for identification with the melt. Each set of specimens so cast shall be placed in some one oven containing castings to be annealed.

Number of Tests

After annealing, three tension test-specimens shall be selected by the inspector as representing the castings in the oven from which these specimens are taken.

Failures

If the first specimen conforms to the specified requirements, or if, in the event of failure of the first specimen, the second and third specimens conform to the requirements, the castings in that oven shall be accepted, except that any casting may be rejected if its test-lug shows that it has not been properly annealed. If either the second or third specimen fails to conform to the requirements, the entire contents of that oven shall be rejected.

Reannealing

Any castings rejected for insufficient annealing may be reannealed once. The reannealed castings shall be inspected and if the remaining test-lugs, or castings broken as specimens, show the castings to be thoroughly annealed, they shall be accepted; if not, they shall be finally rejected.

WORKMANSHIP AND FINISH

Workmanship

The castings shall conform substantially to the patterns or drawings furnished by the purchaser, and also to gages that may be specified in individual cases. The castings shall be made in a workmanlike manner. A variation of ⅛ in. per ft. will be permitted.

Finish

The castings shall be free from injurious defects.

MARKING OF CASTINGS

The manufacturer's identification mark and the pattern numbers assigned by the purchaser shall be cast on all castings of sufficient size, in such positions that they will not interfere with the service of the castings.

INSPECTION AND REJECTION

Inspection

The inspector representing the purchaser shall have free entry at all times to all parts of the manufacturer's works that concern the manufacture of the castings ordered while work on the contract of the purchaser is being performed. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Record of Tests

The manufacturer shall be required to keep a record

[10] This specification is practically the same as specification No. A47-19 of the American Society for Testing Materials.

[11] Tension test-specimens are not machined.

of each melt from which castings are produced, showing tensile-strength and elongation of test-specimens cast from such melts. These records shall be available and shown to the inspector whenever required.

Rejection

Castings that show injurious defects subsequent to their acceptance at the manufacturer's works may be rejected, and, if rejected, shall be replaced by the manufacturer free of cost to the purchaser.

Part VI—Definitions

(General Information)

Normalizing—Heating above the upper critical temperature followed by cooling freely in air.

Annealing—Heating above the upper critical temperature followed by slow cooling as desired.

Quenching—The operation of rapidly cooling in a suitable medium.

Drawing—Reheating after quenching for hardening, to some temperature below the lower limit of the critical range, followed by cooling as desired.

Case-Hardening—The operation of carburizing steel to a predetermined depth of case and subjecting it to a subsequent heat-treatment.

Carburizing—The operation of causing the absorption of carbon by steel when heated below its melting point in contact with carbonaceous material.

Case—The outer portion of a carburized part that has absorbed carbon from the carburizing medium.

Core—The inner portion of a carburized part that has not absorbed carbon from the carburizing medium.

Cyaniding—The operation of case-hardening by which the carburizing is accomplished by heating the steel in a melted cyanide salt.

Cold-Working—The operation of forming the metal, without the application of heat, by rolling, hammering, drawing, pressing or other means to obtain accurate size, fine finish or increased strength.

Hot-Working — The operation of rolling, hammering, pressing or extruding metal which has been made plastic by heating.

Yield-Point—The load per unit of original cross-section at which a marked increase in the deformation of the specimen occurs without increase of load. It is usually calculated from the load determined by the drop of the beam of the testing machine or by the use of dividers.

Tensile-Strength—The maximum load per unit of original cross-sectional area obtained before rupture.

Percentage Elongation—The percentage of increase in length of a tension test-specimen after rupture.

Percentage Reduction of Area—The percentage of decrease of cross-sectional area of a tension test-specimen after rupture.

Shore Hardness—The reading on a conventional scale determined by the rebound of the hammer of the Shore scleroscope on striking the surface of the specimen. (See proposed recommendation)

Brinell Hardness — The number obtained from the ratio between the load applied on and the spherical area of the impression made by a steel ball forced into the surface of the material tested. (See proposed recommendation)

Part VII—Test-Specimens

(Proposed Revision of S.A.E. Standard)

S.A.E. Steels shall be purchased on the basis of requirements as to chemical composition, and the specifications provided herein should be used in the purchase of the grades and types of steel covered by each. When the steel user desires physical tests on forged parts, bars or billets, the test-specimens shall be selected and prepared in accordance with the following standards.

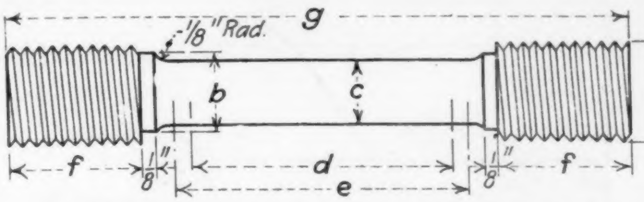


FIG. 12—PROPORTIONAL-SIZE ROUND TENSION TEST-SPECIMEN

Diameter of Stock, in.	½ to ¾	⅜ to ½	¼ to ⅜
a, in.	0.500	0.375	0.250
b, in.	0.391	0.281	0.172
Diameter over Gage-Length (*c*), in.	0.375	0.250	0.125
Gage-Length (*d*), in.	1.500	1.000	0.500
e, in.	1.750	1.250	0.750
f, in. (Approximately)	0.750	0.500	0.375
g, in. (Approximately)	3.625	2.625	1.875

CONSTRUCTION

Tension and bend test-specimens shall be taken from the rolled or forged material, except that in the case of irregularly shaped forgings, they may be taken from a full-size prolongation. Test-specimens shall not be annealed or otherwise treated, except as specified in the following paragraph. Bend tests shall be made cold.

Tension and bend test-specimens for material that is to be annealed or otherwise treated before use shall, for rolled material, be cut from properly annealed or similarly treated short lengths of the full section of the piece and for forged material from the treated forgings.

The axis of tension and bend test-specimens for rolled bars and forgings of uniform cross-section of over 1½-in. thickness or diameter and for forgings of irregular sections shall, when practicable, be located at any point midway between the center and the outer surface when solid, and at any point midway between the inner and outer surfaces of the wall when bored, and shall be parallel to the axis of the piece in the direction in which the metal is most drawn out. Round tension test-specimens shall be machined to the form and dimensions shown in Fig. 9. The gage-length and fillets shall be ground or lap-polished free from scratches. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Plain ends for grips, threaded ends or self-aligning ball-ends may be used.

The bend test-specimens shall be ½ in. square in section and not over 6 in. in length with corners rounded to a radius of not over 1/16 in.

The axis of tension test-specimens for rolled bars and forgings of uniform cross-section 1½ in. or under in thickness or diameter shall be machined concentrically from the specimen. Round tension test-specimens may be machined to the form and dimensions shown in Fig. 9 or may be of larger dimensions provided the length of the pull-section equals 4½ times the square root of the area. The gage-length and fillets shall be ground or lap-polished free from scratches. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Plain ends for grips, threaded ends or self-aligning ball-ends may be used.

Bend test-specimens shall be ½ in. square in section and not over 6 in. in length with corners rounded to a radius of not over 1/16 in.

Round tension test-specimens for rolled bars or forgings of dimensions too small to permit the use

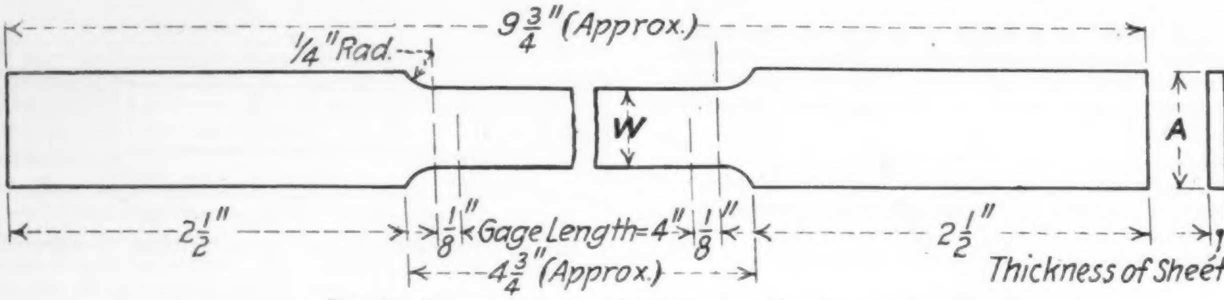


FIG. 13—PROPORTIONAL-SIZE FLAT TENSION TEST-SPECIMEN

	Up to 0.15	Over 0.15 to 0.50
Thickness of Sheet, in.	Up to 0.15	0.50
Gage-Width (W), in.	0.50	0.75
Width of Grip (A), in.	0.75	1.00

of the standard full-size test-specimen, may be machined to the dimensions of the proportional-size round test-specimens shown in Fig. 12 and the accompanying table. The gage-length and fillets shall be ground or lap-polished free from scratches. The ends shall be of a form to fit the holders of a testing-machine in such a way that the load will be axial. Threaded or self-aligning ball-ends may be used. Plain-ends for grips are not recommended.

Flat tension and bend test-specimens for plates and shapes shall be of the full thickness of material as rolled and tensile test-specimens shall be machined to the form and dimensions shown in Fig. 10. The gage-width of test-specimens ¼ in. or less in thickness should be equal to five times the thickness, except that in no case shall the width be less than ¾ in. The gage-length should equal 24 times the thickness of the test-specimen, except that in no case shall it be less than 2 in. The gage-length on test-specimens shall be finished on all sides smooth and free from scratches.

Flat tension test-specimens for shapes or sheets of dimensions too small to permit the use of the standard full-size test-specimen may be machined to the dimensions of the proportional-size flat tension test-specimen shown in Fig. 13 and the accompanying table. The gage-length and fillets shall be ground or lap-polished free from scratches.

Tension test-specimens for malleable castings as specified in that specification shall conform to the shape and dimensions shown in Fig. 11 and shall *not* be machined.

NUMBER OF TESTS

Unless otherwise specified by the purchaser, one tension and one bend test shall be made from each melt; except that if material rolled from one melt differs ⅜ in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material.

If any test-specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another test-specimen in its stead.

If the percentage of elongation of any tension test-specimen is less than that specified and any part of the fracture is more than ¾ in. from the center of the gage length of a 2-in. test-specimen or is outside the middle third of the gage-length of an 8-in. test-specimen, as indicated by divider scratches marked on the test-specimen before testing, a retest shall be allowed.

Part VIII—Hardness Tests

BRINELL HARDNESS TEST

(Proposed Revision of S.A.E. Recommended Practice)

Test Ball—The diameter of the ball shall be 10 mm., ± 0.0025 mm. (0.39370 in. ± 0.00098 in.). The weight applied shall be 3000 kg. (6600 lb.) for 30 sec.

Test Impression—The average diameter of the impression shall be obtained from two measurements at right angles to each other, made with an instrument having a reading error not over 0.05 mm. (0.001969 in.).

Test-Specimen—The surface of the specimen shall be free from scratches. The specimen shall be taken deep enough to represent the true composition of the material to be tested, and shall be maintained

BRINELL HARDNESS NUMBERS

Diameter of Impression, mm.	Brinell Hardness Numbers Loads in Kg.		Diameter of Impression, mm.	Brinell Hardness Numbers Loads in Kg.		Diameter of Impression, mm.	Brinell Hardness Numbers Loads in Kg.		Diameter of Impression, mm.	Brinell Hardness Numbers Loads in Kg.	
	3000	500		3000	500		3000	500		3000	500
2.00	945	158	3.25	352	59	4.50	179	30	5.75	105	18
2.05	899	150	3.30	341	57	4.55	174	29	5.80	103	17
2.10	857	143	3.35	331	55	4.60	170	28	5.85	101	17
2.15	817	136	3.40	321	53	4.65	167	28	5.90	99	17
2 20	780	130	3.45	311	52	4.70	163	27	5.95	97	16
2.25	745	124	3.50	302	50	4.75	159	27	6.00	96	16
2.30	712	119	3.55	293	49	4.80	156	26	6.05	94	16
2.35	682	114	3.60	285	48	4.85	152	25	6.10	92	15
2.40	654	109	3.65	277	46	4.90	149	25	6.15	90	15
2.45	627	104	3.70	269	45	4.95	146	24	6.20	89	15
2.50	602	100	3.75	262	44	5.00	143	24	6.25	87	15
2.55	578	96	3.80	255	42	5.05	140	23	6.30	86	14
2.60	555	93	3.85	248	41	5.10	137	23	6.35	84	14
2.65	534	89	3.90	241	40	5.15	134	22	6.40	83	14
2.70	514	86	3.95	235	39	5.20	131	22	6.45	81	14
2.75	495	83	4.00	229	38	5.25	128	21	6.50	80	13
2.80	478	80	4.05	223	37	5.30	126	21	6.55	78	13
2.85	461	77	4.10	217	36	5.35	123	21	6.60	77	13
2.90	444	74	4.15	212	35	5.40	121	20	6.65	75	13
2.95	429	72	4.20	207	34	5.45	118	20	6.70	74	12
3.00	415	69	4.25	201	34	5.50	116	19	6.75	73	12
3.05	401	67	4.30	197	33	5.55	114	19	6.80	72	12
3.10	388	65	4.35	192	32	5.60	111	19	6.85	70	12
3.15	375	63	4.40	187	31	5.65	109	18	6.90	69	12
3.20	363	61	4.45	183	31	5.70	107	18	6.95	68	11
									7.00	67	11

in a plane normal to the direction of the testing load.

Exceptions—This test should not be used on soft steels less than ½ in. thick or on areas small enough to permit deflection of the edges of the specimen owing to the flow from the ball depression.

SHORE HARDNESS TEST

(Proposed General Information)

The Shore hardness number is the reading obtained on an arbitrary scale ranging from 0 to 120, by the rebound of a small diamond-pointed hammer dropped from a fixed height. Two types of instrument are in common use; one in which the rebound is read directly on a vertical scale, and the other on which the reading is registered by the instrument on a recording dial. It is suggested that, unless special means are used to compensate for the variations in mass, form, surface, composition and physical condition of different specimens being tested, the user determine for himself the characteristic readings obtained on his particular product.

The scleroscope values shown in the accompanying charts of physical properties are average values obtained with the bulb or vertical-scale type of instrument under the conditions described in the Notes, the specimens tested having carefully polished, level surfaces, which are essential in obtaining satisfactory results.

Part IX—General Heat-Treatments

(Proposed Revision of General Information)

In applying detailed heat-treatments as outlined in this report it is recommended, in order to obtain uniform physical properties, that the final quench be made from the lowest temperature that will develop the maximum physical properties, bearing in mind that with thinner sections lower temperatures are required than with thicker sections.

CASE-HARDENING

Heat-Treatments I to V

The process of carburizing as considered in these Notes refers to the dry or pack method and does not take into consideration carburizing by the liquid or gaseous methods. The last two methods have extensive application but the operations depend to such a large extent on individual conditions such as size, shape and use for which these are intended that they cannot be covered by these general Notes.

The process of carburizing is usually divided into two methods.

(1) Quenching directly from the box
(2) Cooling slowly in the box

The first method prevents the formation of a cementite network and large grain-growth. The second method tends in many instances to lessen distortion but does not prevent the formation of a cementite network and large grain-growth. In Heat-Treatment V the first reheat, operation 3, is applied to refine the core and has a beneficial effect on the case. These two general methods are subdivided into specific types of heat-treatments that are applicable for parts of various compositions, shapes, uses and importance.

In case-hardening heat-treatments the drawing operation is not always used in commercial practice, but it is recommended in all cases as being in accord with the best metallurgical practice.

PHYSICAL PROPERTIES AND HEAT-TREATMENTS

Physical-Property Charts

In interpreting the charts of physical properties given

CASE-HARDENING TREATMENTS

Heat-Treatment I
1—Carburize
2—Quench
3—Draw

Heat-Treatment II
1—Carburize
2—Quench
3—Reheat
4—Quench
5—Draw

Heat-Treatment III
1—Carburize
2—Quench
3—Reheat
4—Quench
5—Reheat
6—Quench
7—Draw

Heat-Treatment IV
1—Carburize
2—Cool in box
3—Reheat
4—Quench
5—Draw

Heat-Treatment V
1—Carburize
2—Cool in box
3—Reheat
4—Quench
5—Reheat
6—Quench
7—Draw

HARDENING AND TOUGHENING TREATMENTS

Heat-Treatment VI
1—Heat
2—Quench
3—Draw

Heat-Treatment VII
1—Normalize
2—Reheat
3—Quench
4—Draw

Heat-Treatment VIII
1—Normalize
2—Reheat
3—Cool in furnace
4—Machine
5—Reheat
6—Quench
7—Draw

in this report in Figs. 14 to 38 the following considerations should always be borne in mind.

The charts have been made as valuable as possible to the engineer by indicating what can be expected as the average product of a given composition when treated in the specific manner in 1½-in. sections. Generally on sizes larger than 1½ in., lower values will prevail and on sizes smaller than 1½ in., higher values will prevail. At the same time the data for the charts have been chosen so as to protect makers of heat-treated stock and parts from unreasonable demands.

For the sake of simplicity it has seemed advisable to use only average minimum figures for tensile-strength, yield-point, reduction of area and elongation, based on the following considerations, heat-treatment being constant:

(1) The lowest yield-points and tensile-strengths are produced with steels at the bottom of a given range in carbon
(2) The lowest reductions in area and elongations are produced with steels at the top of a given range in carbon

Thus, for Steel 1035, the average minimum yield-points and tensile-strengths are given as of a steel containing 0.30 per cent carbon; average minimum reductions of area and elongations as of a steel containing 0.40 per cent carbon.

The figures for hardness are conventional averages for the whole range of compositions within any given specification.

The charts include treatments and conservative physical tests on all S.A.E. Steels for which such charts have been prepared. For these charts the following applies:

(1) They indicate the physical properties which may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars of 1½-in. diameter or square
(2) Heat-treatments given in the charts apply to rolled bars that were normalized or otherwise treated prior to heating and quenching as shown on individual charts

(3) Test-bars 0.505 in. in diameter and 2 in. long, machined from rolled bars after final treatment and tested under normal commercial conditions
(4) Brinell and scleroscope readings were taken at a distance from the center equal to half the radius and are not to be compared with surface readings on heat-treated bars or parts.

S.A.E. Steels 1010 *and* 1015

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	1010	1015
Carbon	0.05-0.15	0.10-0.20
Manganese	0.30-0.60	0.30-0.60
Phosphorus	0.045 max.	0.045 max.
Sulphur	0.05 max.	0.05 max.

These steels are commonly used for seamless tubing and pressed-steel parts of many varieties. They are soft and ductile and will stand much deformation without cracking.

In a natural or annealed condition, these steels have low tensile-strength and should not be used where much strength is required. They are considerably stronger after cold-working; that is, the yield-point is raised by such working. This is important in view of the fact that many parts are used in cold-worked condition.

These compositions, when in the natural or annealed condition, should have the following approximate physical properties:

Yield-Point, lb. per sq. in.	28,000 to 36,000
Elongation in 2 In., per cent	40 to 30
Reduction of Area, per cent	65 to 55

It should be borne in mind that when these steels in cold-worked condition are heated for bending, brazing, welding or such operations the yield-point returns to that which is characteristic of the annealed or hot-worked material. This applies also to all materials the yield-point of which is increased by cold-working.

These steels do not machine freely. They will tear badly in turning, threading and broaching operations. It is possible, by quenching them in water from 1700 deg. fahr., no draw being required, to improve their machining qualities over those in the annealed condition. Such heat-treatment, however, produces very little increase in strength. These steels can be used for case-hardening, Heat-Treatment I being used when the strength of the core is not important.

Heat-Treatment II is recommended when maximum hardness only is required and distortion is not important. When maximum hardness of case and refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the case and the least possible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and the core is desired, distortion not being important, Heat-Treatment V may be used.

Heat-Treatment 1010-*I and* 1015-*I*
1—Carburize at 1650 to 1700 deg. fahr.
2—Quench
3—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1010-*II and* 1015-*II*
1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1010-*III and* 1015-*III*
1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box
3—Reheat to 1650 to 1700 deg. fahr.
4—Quench
5—Reheat to 1400 to 1450 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1010-*IV and* 1015-*IV*
1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1010-*V and* 1015-*V*
1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1650 to 1700 deg. fahr.
4—Quench
5—Reheat to 1400 to 1450 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

S.A.E. Steel 1020

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.30-0.60
Phosphorus	0.045 max.
Sulphur	0.05 max.

This steel is known to the trade as 0.20 carbon open-hearth steel, and often as machine steel. It forges well and machines better than S.A.E. Steels 1010 and 1015 but should not be considered as screw-machine stock. It can be used for a very large variety of forged, machined and case-hardened automotive parts where strength is not paramount.

Steel of this quality can be drawn into tubes and cold-rolled into forms and shapes for automotive parts. It can be also safely used interchangeably with S.A.E. Steels 1010 and 1015 for cold-worked shapes that do not require deep drawing.

When cold-worked, this steel will have a yield-point of 40,000 to 80,000 lb. per sq. in. in round sections not over ½ in. in diameter or in sheets or flats ¼ in. thick. Heat-treatment of this steel produces a desirable refinement of grain after rolling or forging. The following heat-treatment will often help the machining qualities of hot-rolled and forged stock:

Heat-Treatment 1020-*VI*
1—Heat to 1575 to 1675 deg. fahr.
2—Quench in water
3—Draw to required hardness

Case-hardening is the most important heat-treatment for this quality of steel. The particular case-hardening treatment depends upon the importance of the part to be treated and its shape and size. When hardness only is required, such parts may be subjected to Heat-Treatment II; when maximum hardness of the case and refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used;

when a refined case and minimum distortion are required, Heat-Treatment IV should be used; when maximum refinement of both the case and the core is required Heat-Treatment V should be used.

When this steel is used for gears for which a high degree of accuracy and considerable strength are required, it is recommended that the carburizing operation be preceded by normalizing at 1650 to 1750 deg. fahr., which will improve the structure and tend to reduce the distortion caused by subsequent treatments.

Heat-Treatment 1020-*I*

1—Carburize at 1650 to 1700 deg. fahr.
2—Quench
3—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1020-*II*

1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1020-*III*

1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box
3—Reheat to 1600 to 1650 deg. fahr.
4—Quench
5—Reheat to 1400 to 1450 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1020-*IV*

1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 1020-*V*

1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1600 to 1650 deg. fahr.
4—Quench
5—Reheat to 1400 to 1450 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

[For physical-property chart see Fig. 14]

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.30-0.60
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1600 to 1650 deg. fahr. in *water.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½*-in. diameter or square, this chart does not apply.*

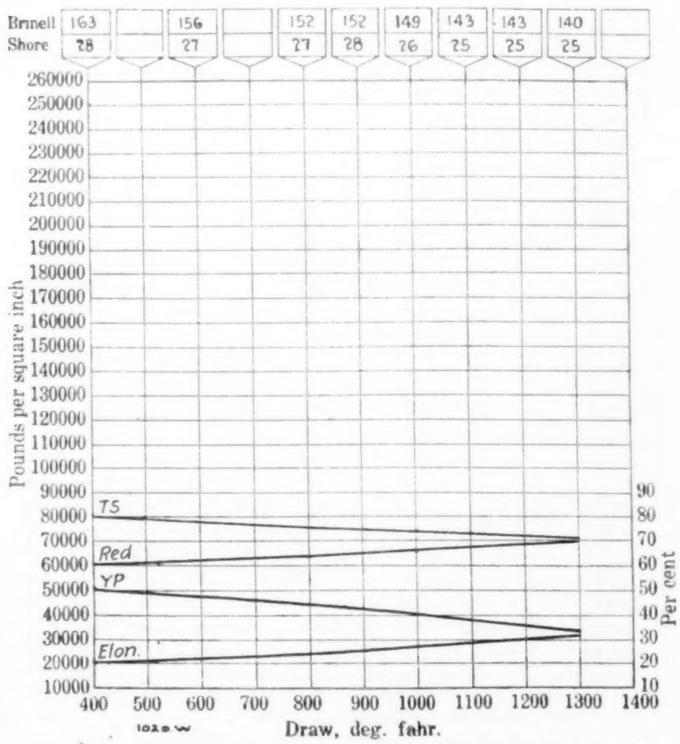


Fig. 14—Physical-Property Chart of S.A.E. Steel No. 1020 Quenched in Water

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.20-0.30
Manganese	0.50-0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1575 to 1650 deg. fahr. in *water.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½*-in. diameter or square, this chart does not apply.*

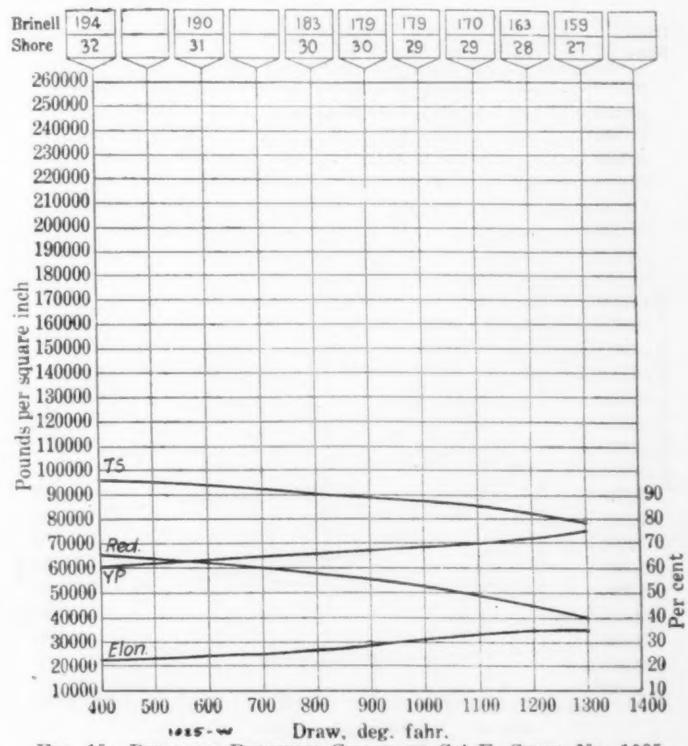


Fig. 15—Physical-Property Chart of S.A.E. Steel No. 1025 Quenched in Water

S.A.E. Steels 1025 *and* 1030

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	1025	1030
Carbon	0.20-0.30	0.25-0.35
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.045 max.	0.045 max.
Sulphur	0.05 max.	0.05 max.

These steels will respond to heat-treatment better than Steel 1020. They can be used, therefore, for forged, machined or cold-worked parts requiring slightly higher physical properties than are obtainable with Steel 1020 and will have better machining qualities.

These steels should not be used for parts that are to be carburized. Heat-Treatment VI is recommended.

Heat-Treatment 1025-*VI and* 1030-*VI*
1—Heat to 1575 to 1650 deg. fahr.
2—Quench in water
3—Draw to required hardness

Where the maximum of uniformity in machining and in physical properties is desired, Heat-Treatment VII is recommended.

Heat-Treatment 1025-*VII and* 1030-*VII*
1—Normalize at 1700 to 1800 deg. fahr.
2—Heat to 1575 to 1650 deg. fahr.
3—Quench in water
4—Draw to required hardness

[For physical-property chart see Fig. 15]

S.A.E. Steels 1035 *and* 1040

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.30-0.40
Manganese	0.50-0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1525 to 1575 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½-*in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-*in. diameter or square, this chart does not apply.*

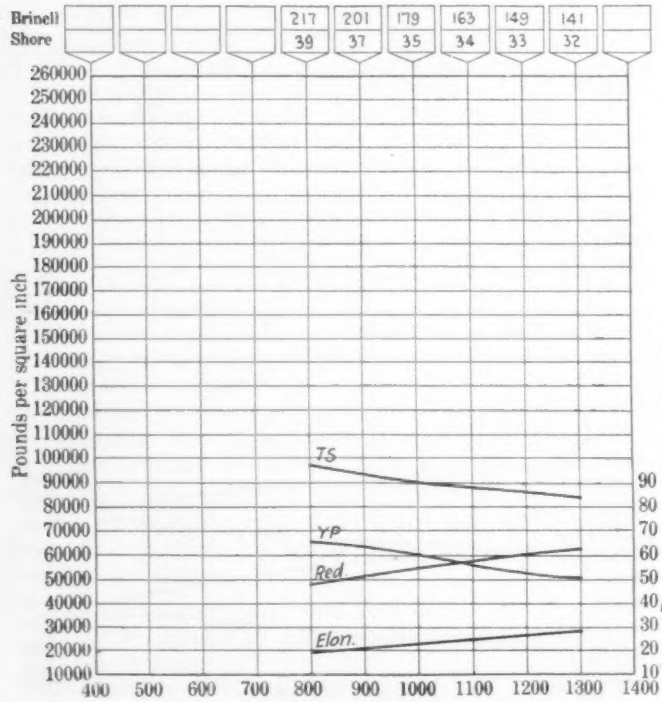


Fig. 16—Physical-Property Chart of S.A.E. Steel No. 1035 Quenched in Oil

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.30-0.40
Manganese	0.50-0.80
Phosphorus	0.45 max.
Sulphur	0.05 max.

Quenched at 1525 to 1575 deg. fahr. in *water.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½-*in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-*in. diameter or square, this chart does not apply.*

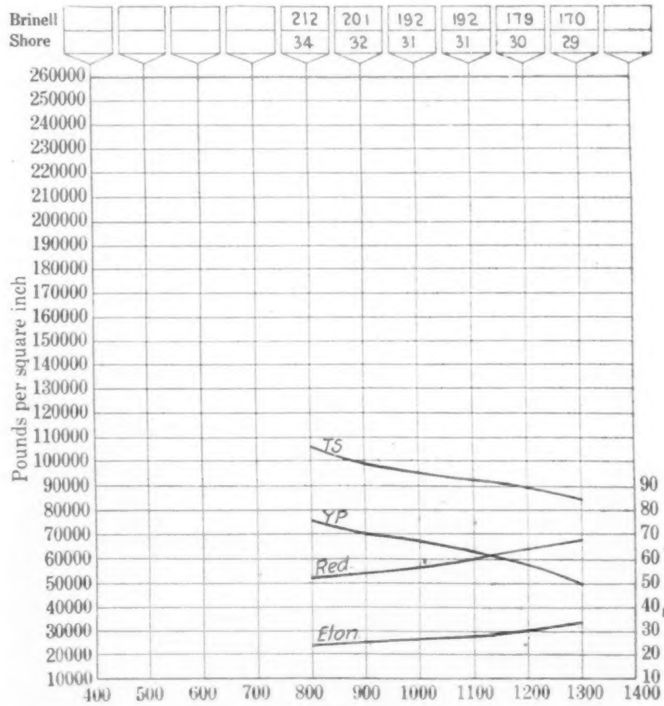


Fig. 17—Physical-Property Chart of S.A.E. Steel No. 1035 Quenched in Water

of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	1035	1040
Carbon	0.30-0.40	0.35-0.45
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.045 max.	0.045 max.
Sulphur	0.05 max.	0.05 max.

These are medium carbon steels possessing good machining properties and are suitable for small and medium sizes of plain carbon-steel forgings where moderate physical properties are desired. For general purposes Heat-Treatment VI is satisfactory.

Heat-Treatment 1035-*VI and* 1040-*VI*

1—Heat to 1525 to 1575 deg. fahr.
2—Quench
3—Draw to required hardness

Where maximum development of physical properties is desired as in the larger sizes of forgings Heat-Treatment VII is recommended.

Heat-Treatment 1035-*VII and* 1040-*VII*

1—Normalize at 1650 to 1750 deg. fahr.
2—Heat to 1525 to 1575 deg. fahr.
3—Quench
4—Draw to required hardness

[For physical-property charts see Figs. 16 and 17]

S.A.E. Steels 1045, 1046 *and* 1050

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	1045	1046	1050
Carbon	0.40-0.50	0.40-0.50	0.45-0.55
Manganese	0.50-0.80	0.30-0.50	0.50-0.80
Phosphorus	0.045 max.	0.045 max.	0.045 max.
Sulphur	0.05 max.	0.05 max.	0.05 max.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.40-0.50
Manganese	0.50-0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1475 to 1525 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½-*in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-*in. diameter or square, this chart does not apply.*

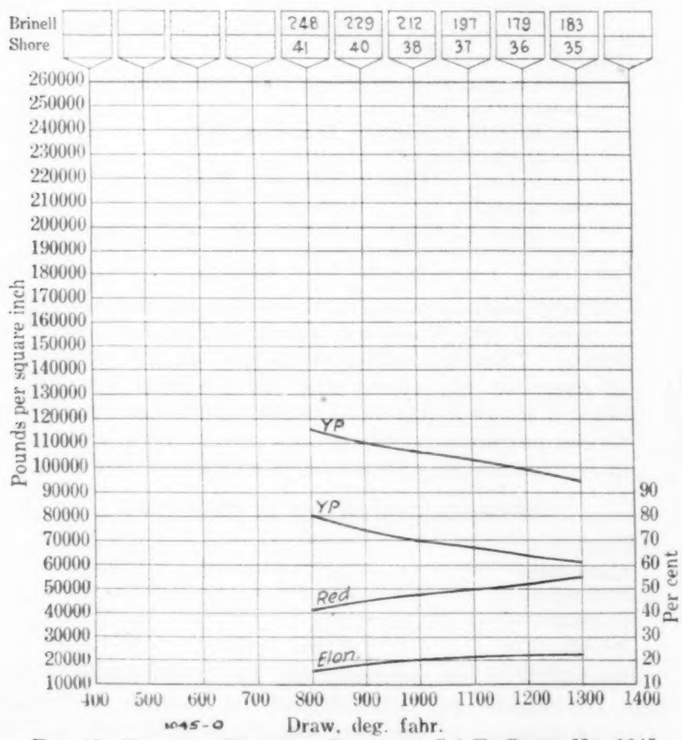


FIG. 18—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 1045 QUENCHED IN OIL

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.40-0.50
Manganese	0.50-0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1475 to 1525 deg. fahr. in *water.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½-*in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-*in. diameter or square, this chart does not apply.*

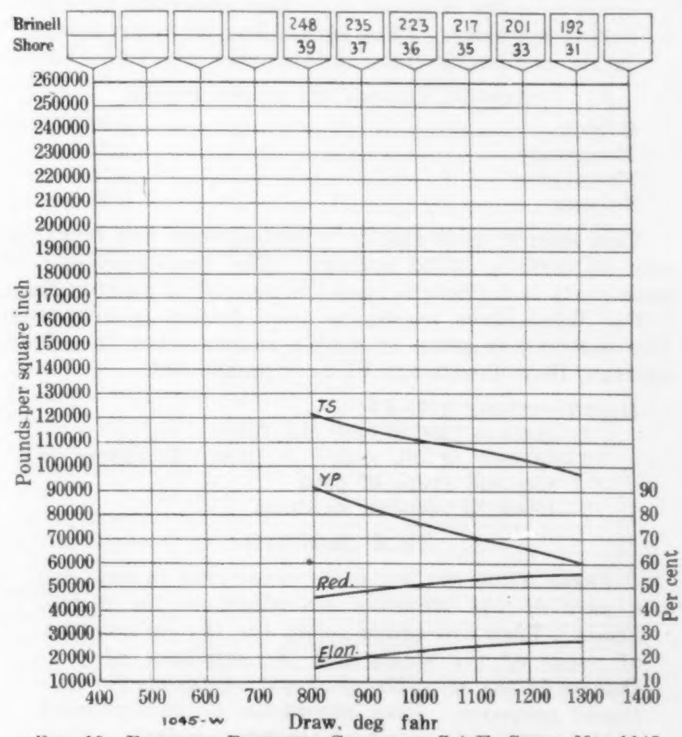


FIG. 19—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 1045 QUENCHED IN WATER

These are medium carbon steels intended for the larger sizes of plain carbon-steel forgings used in automotive construction. They can also be used for a wide range of parts machined from bar stock.

Steel 1046 is the same as Steel 1045 except for a lower manganese-content and is intended for gears that are to be water-quenched.

For general purposes Heat-Treatment VI will produce the desired physical properties.

Heat-Treatment 1045-*VI*, 1046-*VI and* 1050-*VI*

1—Heat to 1500 to 1550 deg. fahr.
2—Quench in oil or water, depending upon size and shape of part
3—Draw to required hardness

Where maximum development of physical properties is desired, Heat-Treatment VII is recommended.

Heat-Treatment 1045-*VII*, 1046-*VII and* 1050-*VII*

1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1475 to 1525 deg. fahr.
3—Quench in oil or water, depending upon size and shape of part
4—Draw to required hardness

For parts such as gears that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 1045-*VIII*, 1046-*VIII and* 1050-*VIII*

1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1400 to 1450 deg. fahr.
3—Cool in furnace
4—Machine
5—Reheat to 1475 to 1525 deg. fahr.
6—Quench
7—Draw to required hardness

[For physical-property charts see Figs. 18 and 19]

S.A.E. Steel 1095

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.90-1.05
Manganese	0.25-0.50
Phosphorus	0.04 max.
Sulphur	0.05 max.

This steel is used chiefly in leaf-springs and occasionally in certain coiled springs. The heat-treatment of such parts is dependent upon the method of manufacture.

For those cases where the user desires to heat-treat this material in plain or simple shapes other than leaf-springs, Heat-Treatment VI is recommended.

Heat-Treatment 1095-*VI*

1—Heat to 1400 to 1450 deg. fahr.
2—Quench in oil, water or brine, depending on size and shape of part
3—Draw to required hardness

S.A.E. Steel 2315

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.10-0.20
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

This steel is intended primarily for case-hardening. Parts made from it may be subjected to Heat-Treatment II when maximum hardness only is required and distortion is not important; to Heat-Treatment III when maximum hardness of the case and maximum refinement of both the case and the core are desired, distortion again being unimportant; to Heat-Treatment IV when hardness, refinement of the case and the least possible distortion are required; and to Heat-Treatment V when refinement of both the case and the core is desired, distortion not being important.

When these steels are used for gears for which a high degree of accuracy and strength is required, it is recommended that the carburizing operation be preceded by normalizing at 1650 to 1750 deg. fahr., which will improve the structure and tend to reduce the distortion caused by subsequent treatments.

Heat-Treatment 2315-*II*

1—Carburize at 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1350 to 1400 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 2315-*III*

1—Carburize at 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1500 to 1550 deg. fahr.
4—Quench in oil
5—Reheat to 1350 to 1400 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 2315-*IV*

1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1375 to 1425 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 2315-*V*

1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1500 to 1550 deg. fahr.
4—Quench in oil
5—Reheat to 1350 to 1400 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

S.A.E. Steel 2320

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

Steel 2320 is not recommended for case-hardening except for massive parts because of the sacrifice to ductility and support of the core resulting from the higher

carbon. Subsequent to carbonizing, great care must be exercised in treatments to minimize brittleness of the core.

Carburized parts made from this steel may be subjected to Heat-Treatment II when maximum hardness only is required and distortion is not important. When maximum hardness of the case and maximum refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the case and least possible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and core is desired, distortion not being important, Heat-Treatment V should be used. When these steels are used for gears for which a high degree of accuracy and strength is required, it is recommended that the carburizing operation be preceded by normalizing at 1650 to 1750 deg. fahr., which will improve the structure and tend to reduce the distortion caused by subsequent treatments.

Heat-Treatment 2320-*II*

1—Carburize at 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1350 to 1400 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 2320-*III*

1—Carburize at 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1500 to 1550 deg. fahr.
4—Quench in oil
5—Reheat to 1350 to 1400 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 2320-*IV*

1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1375 to 1425 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

Normalized at 1650 to 1750 deg. fahr.
Quenched at 1475 to 1525 deg. fahr. in *oil*.

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* $1\frac{1}{2}$*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over $1\frac{1}{2}$*-in. diameter or square, this chart does not apply.*

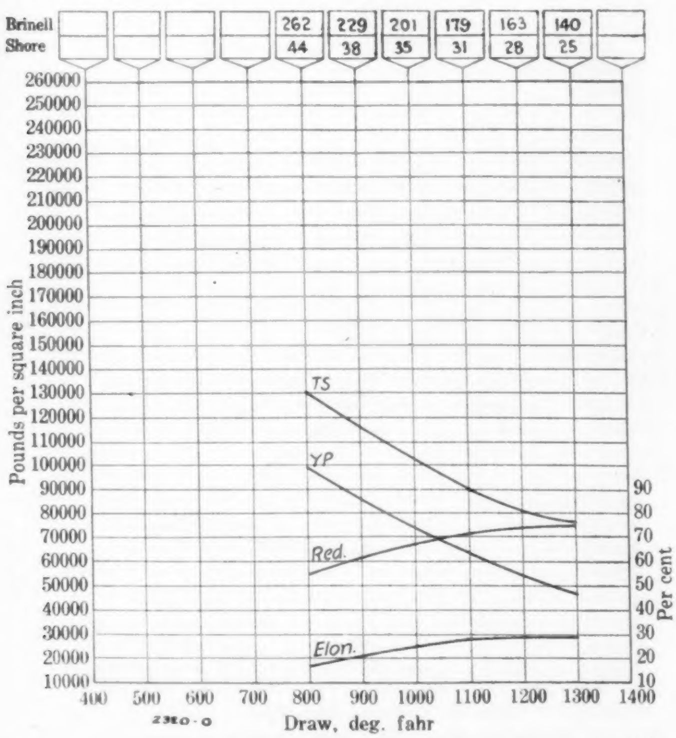


FIG. 20—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 2320 QUENCHED IN OIL

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

Normalized at 1650 to 1750 deg. fahr.
Quenched at 1475 to 1525 deg. fahr. in *water*.

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* $1\frac{1}{2}$*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over $1\frac{1}{2}$*-in. diameter or square, this chart does not apply.*

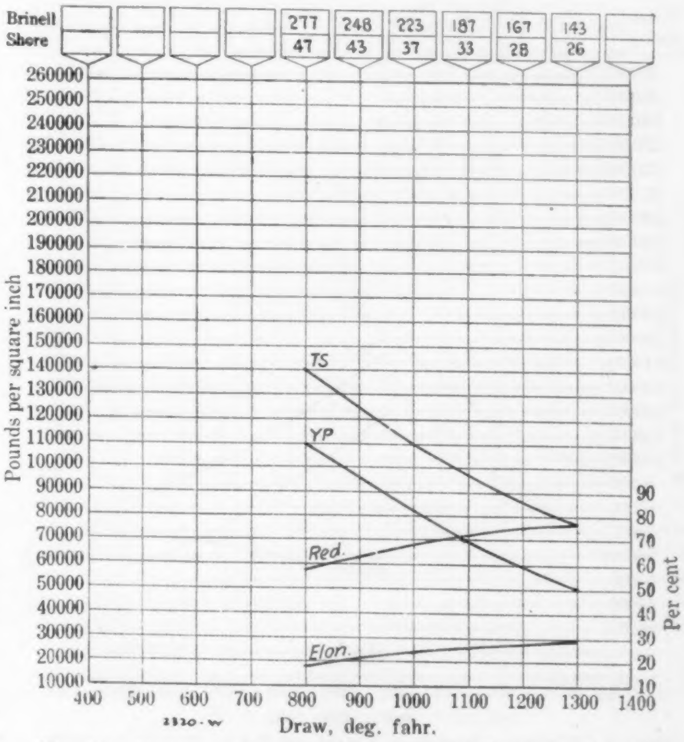


FIG. 21—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 2320 QUENCHED IN WATER

Heat-Treatment 2320-*V*

1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1500 to 1550 deg. fahr.
4—Quench in oil
5—Reheat to 1350 to 1400 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 2320-*VI*

1—Heat to 1475 to 1525 deg. fahr.
2—Quench
3—Draw to required hardness

For structural purposes forged parts should be given Heat-Treatment VII which will develop the desired physical properties.

Heat-Treatment 2320-*VII*

1—Normalize at 1650 to 1750 deg. fahr.
2—Heat to 1475 to 1525 deg. fahr.
3—Quench
4—Draw to required hardness

[For physical-property charts see Figs. 20 and 21]

S.A.E. Steels 2330 *and* 2335

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.25-0.35
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

Normalized at 1650 to 1750 deg. fahr.
Quenched at 1450 to 1500 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½-*in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-*in. diameter or square, this chart does not apply.*

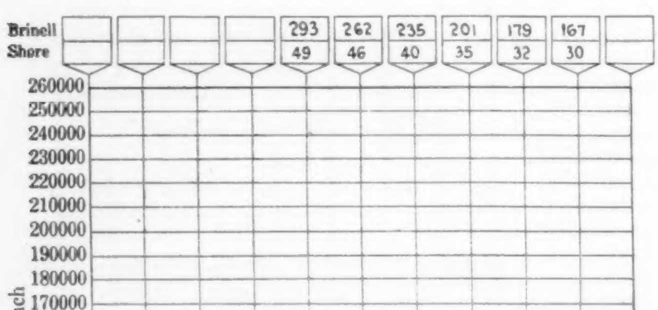


Fig. 22—Physical-Property Chart of S.A.E. Steel No. 2330 Quenched in Oil

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.25-0.35
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

Normalized at 1625 to 1725 deg. fahr.
Quenched at 1450 to 1500 deg. fahr. in *water.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½-*in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-*in. diameter or square, this chart does not apply.*

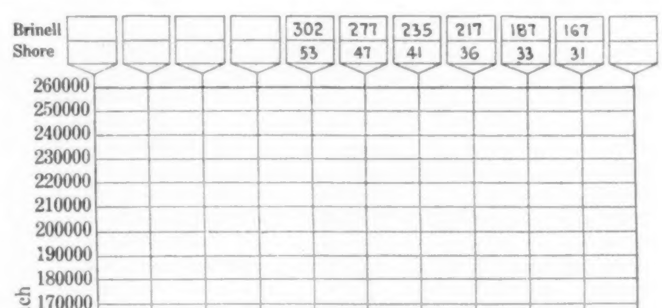


Fig. 23—Physical-Property Chart of S.A.E. Steel No. 2330 Quenched in Water

CHEMICAL COMPOSITION IN PERCENTAGE

Steels	2330	2335
Carbon	0.25-0.35	0.30-0.40
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.045 max.	0.045 max.
Nickel	3.25-3.75	3.25-3.75

These steels are primarily for heat-treated automotive parts when considerable strength and toughness are sought. *They should not be case-hardened.*

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 2330-*VI and* 2335-*VI*

1—Heat to 1450 to 1500 deg. fahr.
2—Quench
3—Draw to required hardness

Heat-Treatment 2330-*VII and* 2335-*VII*

1—Normalize at 1650 to 1750 deg. fahr.
2—Heat to 1450 to 1500 deg. fahr.
3—Quench
4—Draw to required hardness

[For physical-property charts see Figs. 22 and 23]

S.A.E. Steels 2340 *and* 2345

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steels	2340	2345
Carbon	0.35-0.45	0.40-0.50
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.045 max.	0.045 max.
Nickel	3.25-3.75	3.25-3.75

These nickel steels are not widely used, but are available for certain purposes, the carbon content being higher than generally used, greater hardness is obtained by quenching and as increased brittleness accompanies the greater hardness, the heat-treatments given must be modified to meet such conditions.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 2340-*VI and* 2345-*VI*

1—Heat to 1425 to 1475 deg. fahr.
2—Quench
3—Draw to required hardness

Heat-Treatment 2340-*VII and* 2345-*VII*

1—Normalize at 1625 to 1725 deg. fahr.
2—Heat to 1425 to 1475 deg. fahr.
3—Quench
4—Draw to required hardness

For parts that are to be machined after forging and before heat-treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 2345-*VIII*

1—Normalize at 1625 to 1675 deg. fahr.
2—Reheat to 1400 to 1450 deg. fahr.
3—Cool in furnace
4—Machine
5—Reheat to 1425 to 1475 deg. fahr.
6—Quench in oil
7—Draw to required hardness

[For physical-property chart see Fig. 24]

S.A.E. Steel 2350

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.35-0.45
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

Normalized at 1625 to 1725 deg. fahr.
Quenched at 1425 to 1475 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* $1\frac{1}{2}$*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over $1\frac{1}{2}$*-in. diameter or square, this chart does not apply.*

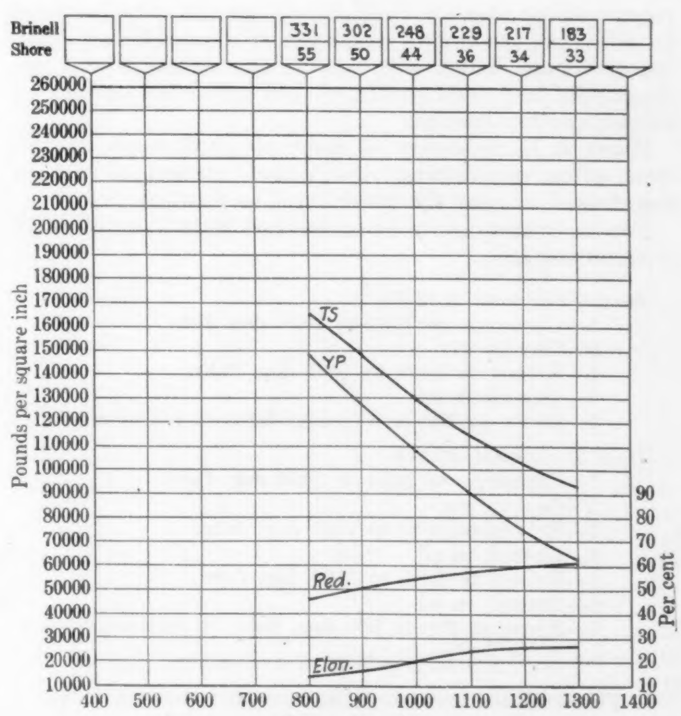


FIG. 24—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 2340 QUENCHED IN OIL

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.45-0.55
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25-3.75

This steel is provided to meet the requirements of gear manufacturers for gears of large section.

For parts, such as gears, that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 2350-*VIII*

1—Normalize at 1600 to 1650 deg. fahr.
2—Reheat to 1375 to 1425 deg. fahr.
3—Cool in furnace
4—Machine
5—Reheat to 1400 to 1450 deg. fahr.
6—Quench in oil
7—Draw to required hardness

S.A.E. Steel 2512

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.17 max.
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	4.50-5.25

This steel is used for case-hardened parts that require an exceptionally tough core after heat-treatment.

When it is used for gears for which a high degree of accuracy and considerable strength are required, it is recommended that the carburizing operation be preceded by either a normalizing treatment or a quench and drawing operation, which will improve the structure and machinability and tend to reduce the distortion caused by subsequent treatments.

When it is necessary to machine parts made of this steel after carburizing, the nickel content should be maintained as near the lower limit as possible.

For parts that are to be carburized Heat-Treatment IV is recommended.

Heat-Treatment 2512-*IV*

1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench in oil
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 2512-*V*

1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1500 to 1550 deg. fahr.
4—Quench in oil
5—Reheat to 1350 to 1400 deg. fahr.
6—Quench in oil
7—Draw at 250 to 500 deg. fahr. is recommended

S.A.E. Steels 3115 *and* 3120

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	3115	3120
Carbon	0.10-0.20	0.15-0.25
Manganese	0.30-0.60	0.30-0.60
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.04 max.	0.045 max.
Nickel	1.00-1.50	1.00-1.50
Chromium	0.45-0.75	0.45-0.75

These steels are intended primarily for case-hardening but can also be used for structural parts with suitable heat-treatment such as VI or VII.

Carburized parts made from these steels may be subjected to Heat-Treatment II when hardness only is required and distortion is not important. When maximum hardness of the case and maximum refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the case and the least possible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and the core is desired, distortion not being important, Heat-Treatment V should be used.

Steel 3120 is not recommended for case-hardening except for massive parts because of the sacrifice to ductility and support of the core resulting from the higher carbon. Subsequent to carbonizing, great care must be exercised in treatments to minimize the brittleness of the core.

When these steels are used for gears for which a high degree of accuracy and considerable strength are required, it is recommended that the carburizing operation be preceded by normalizing at 1650 to 1750 deg. fahr., which will improve the structure and tend to reduce the distortion caused by subsequent treatments.

Heat-Treatment 3115-*II and* 3120-*II*

1—Carburize at 1625 to 1675 deg. fahr.
2—Quench from box in oil
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3115-*III and* 3120-*III*

1—Carburize at 1625 to 1675 deg. fahr.
2—Quench from box in oil
3—Reheat to 1525 to 1575 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3115-*IV and* 3120-*IV*

1—Carburize at 1625 to 1675 deg. fahr.
2—Cool in box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3115-*V and* 3120-*V*

1—Carburize at 1625 to 1675 deg. fahr.
2—Cool in box
3—Reheat to 1525 to 1575 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-

Treatment VII is recommended as the preliminary treatment for all forgings but the desired physical properties of bar stock may be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 3120-*VI*
1—Heat to 1575 to 1625 deg. fahr.
2—Quench
3—Draw to required hardness

Heat-Treatment 3120-*VII*
1—Normalize at 1650 to 1750 deg. fahr.
2—Heat to 1575 to 1625 deg. fahr.
3—Quench
4—Draw to required hardness

[For physical-property charts see Figs. 25 and 26]

S.A.E. Steels 3125 *and* 3130

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	3125	3130
Carbon	0.20-0.30	0.25-0.35
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.045 max.	0.045 max.
Nickel	1.00-1.50	1.00-1.50
Chromium	0.45-0.75	0.45-0.75

These steels may be used interchangeably with Steels 2330 and 2335 for heat-treated automotive parts requiring greater strength and toughness than provided by plain carbon steel. *They should not be used for carburizing.*

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	1.00-1.50
Chromium	0.45-0.75

Quenched at 1575 to 1625 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½*-in. diameter or square, this chart does not apply.*

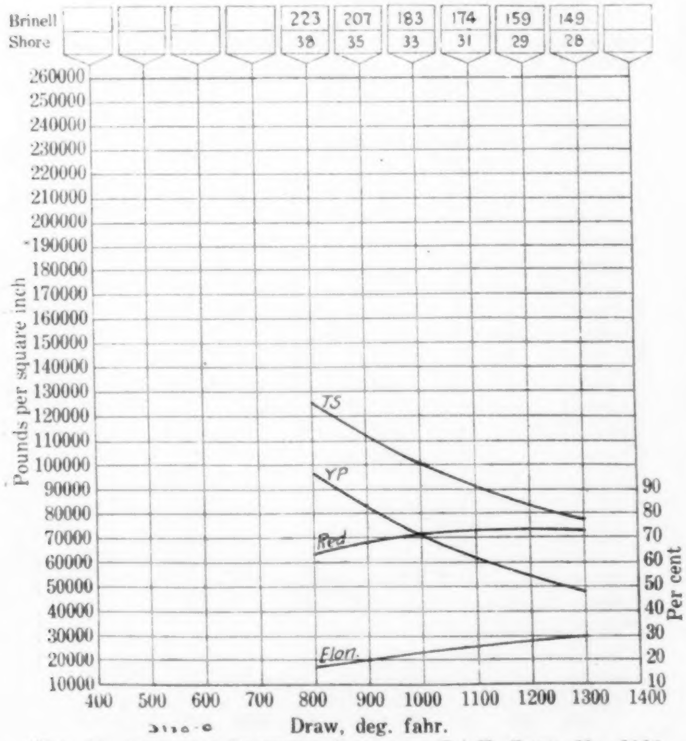


FIG. 25—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3120 QUENCHED IN OIL

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	1.00-1.50
Chromium	0.45-0.75

Quenched at 1575 to 1625 deg. fahr. in *water.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½*-in. diameter or square, this chart does not apply.*

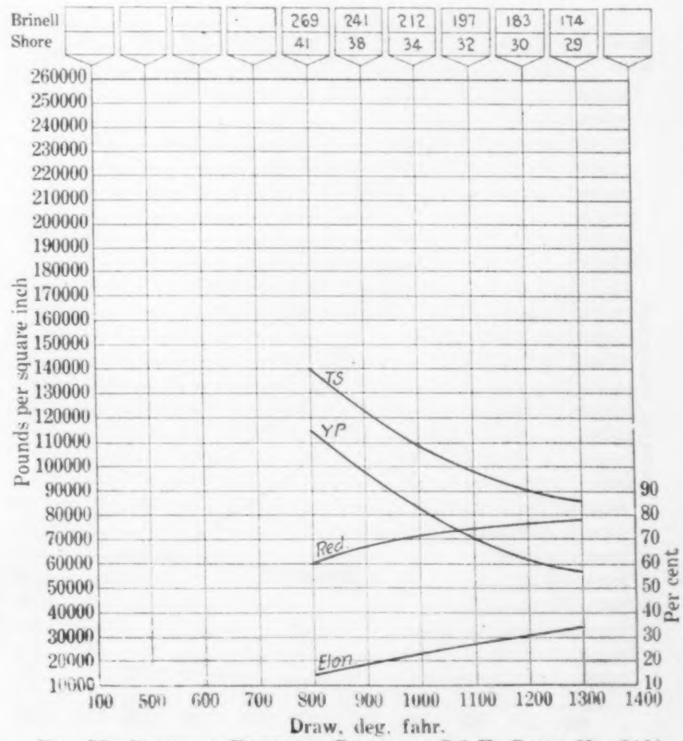


FIG. 26—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3120 QUENCHED IN WATER

or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 3125-*VI and* 3130-*VI*

1—Heat to 1500 to 1550 deg. fahr.
2—Quench
3—Draw to required hardness

Heat-Treatment 3125-*VII and* 3130-*VII*

1—Normalize at 1650 to 1750 deg. fahr.
2—Heat to 1500 to 1550 deg. fahr.
3—Quench
4—Draw to required hardness

[For physical-property charts see Figs. 27 and 28]

S.A.E. Steels 3135 *and* 3140

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	3135	3140
Carbon	0.30-0.40	0.35-0.45
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.045 max.	0.045 max.
Nickel	1.00-1.50	1.00-1.50
Chromium	0.45-0.75	0.45-0.75

These steels may also be used interchangeably with Steels 2340 and 2345 for heat-treated automotive forgings requiring greater strength and toughness than are obtainable with plain carbon steel.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.25-0.35
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	1.00-1.50
Chromium	0.45-0.75

Normalized at 1650 to 1750 deg. fahr.
Quenched at 1500 to 1550 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½*-in. diameter or square, this chart does not apply.*

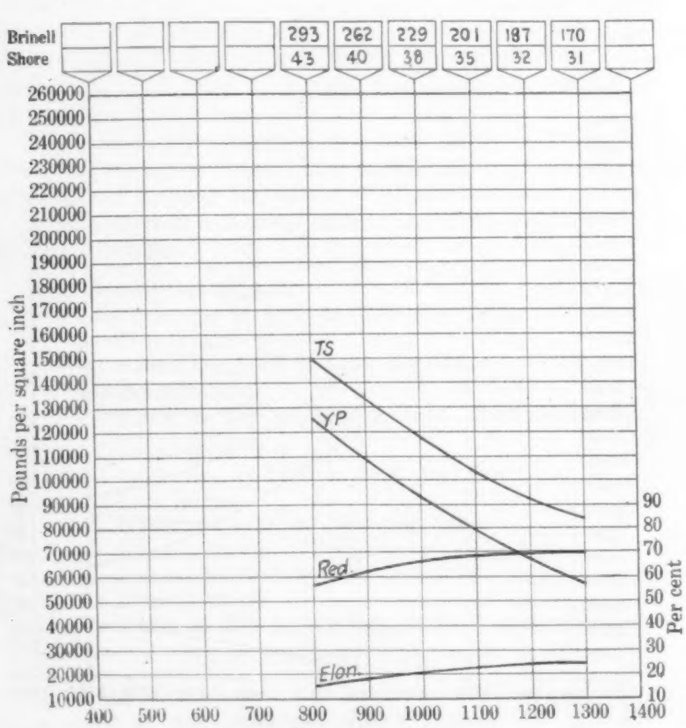


FIG. 27—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL No. 3130 QUENCHED IN OIL

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.25-0.35
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	1.00-1.50
Chromium	0.45-0.75

Normalized at 1650 to 1750 deg. fahr.
Quenched at 1500 to 1550 deg. fahr. in *water*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½*-in. diameter or square, this chart does not apply.*

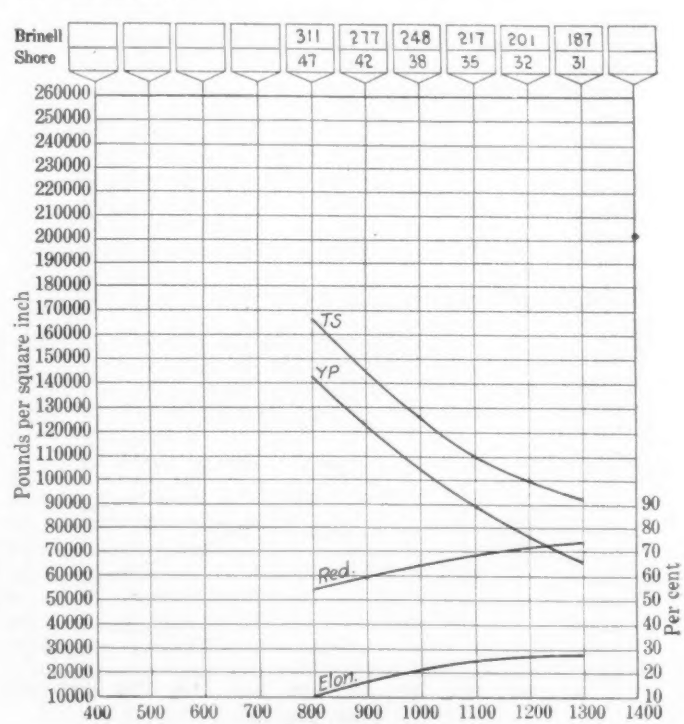


FIG. 28—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL No. 3130 QUENCHED IN WATER

Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 3135-*VI and* 3140-*VI*
1—Heat to 1475 to 1525 deg. fahr.
2—Quench
3—Draw to required hardness

Heat-Treatment 3135-*VII and* 3140-*VII*
1—Normalize at 1625 to 1725 deg. fahr.
2—Heat to 1475 to 1525 deg. fahr.
3—Quench in oil
4—Draw to required hardness

[For physical property chart see Fig. 29]

S.A.E. Steels 3215 *and* 3220

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	3215	3220
Carbon	0.10-0.20	0.15-0.25
Manganese	0.30-0.60	0.30-0.60
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.04 max.	0.04 max.
Nickel	1.50-2.00	1.50-2.00
Chromium	0.90-1.25	0.90-1.25

These steels are intended primarily for case-hardened parts that require a greater strength of core than is obtainable in Steels 3115 and 3120. They can also be used for structural parts after suitable heat-treatment. Their higher chromium content, which causes deeper penetration of the effect of heat-treatment, makes them more

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.35-0.45
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	1.00-1.50
Chromium	0.45-0.75

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1475 to 1525 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* $1\frac{1}{2}$*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over $1\frac{1}{2}$*-in. diameter or square, this chart does not apply.*

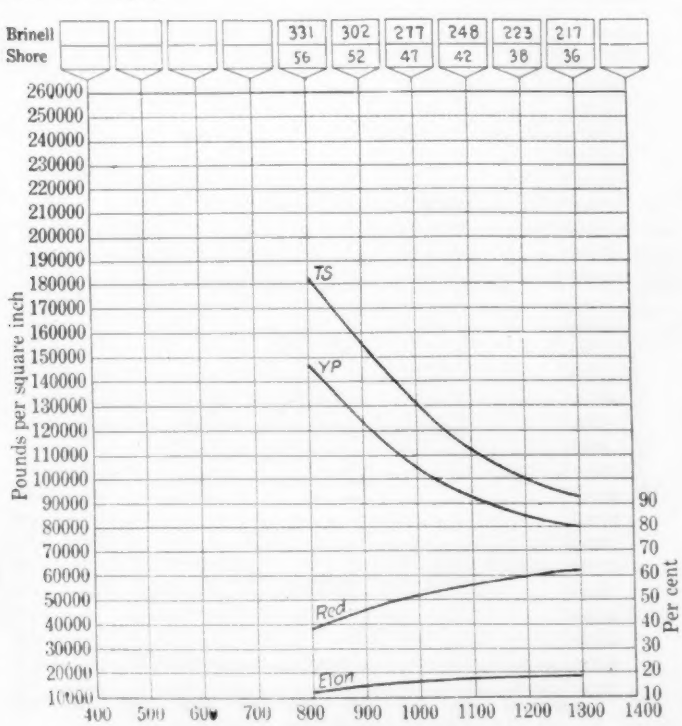


FIG. 29—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3140 QUENCHED IN OIL

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50-2.00
Chromium	0.90-1.25

Normalized at 1625 to 1725 deg. fahr.
Quenched at 1550 to 1600 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* $1\frac{1}{2}$*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over $1\frac{1}{2}$*-in. diameter or square, this chart does not apply.*

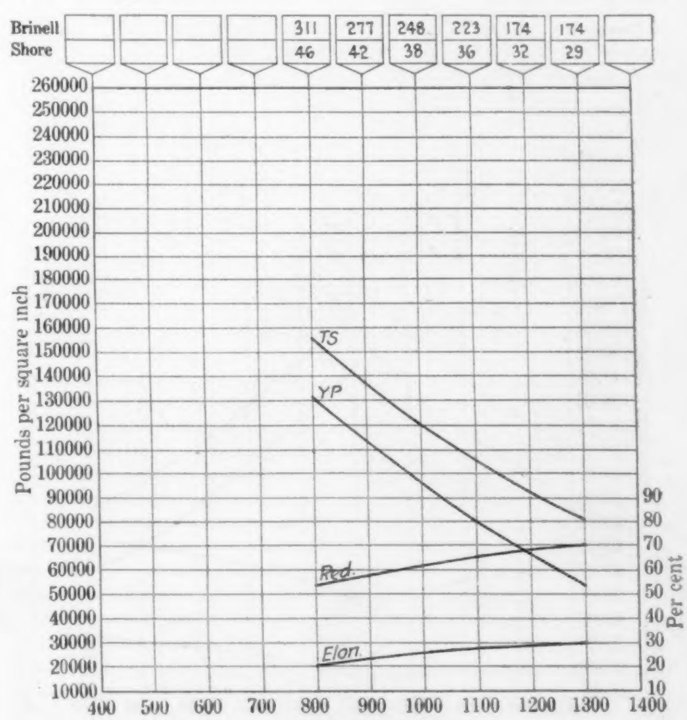


FIG. 30—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3220 QUENCHED IN OIL

suitable for use in heavy sections over 1½-in diameter than Steels 3115 and 3120.

Carburized parts made from these steels may be subjected to Heat-Treatment II when hardness only is required and distortion is not important. When maximum hardness of the case and maximum refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the core and least possible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and the core are desired, distortion not being important, Heat-Treatment V should be used.

Steel 3220 is not recommended for case-hardening except for massive parts because of the sacrifice to ductility and support of the core resulting from the higher carbon. Subsequent to carbonizing, great care must be exercised in treatments to minimize the brittleness of the core.

When these steels are used for gears for which a high degree of accuracy and considerable strength are required, it is recommended that the carburizing operation be preceded by normalizing at 1650 to 1750 deg. fahr., which will improve the structure and tend to reduce the distortion caused by subsequent treatments.

Heat-Treatment 3215-*II and* 3220-*II*

1—Carburize at 1625 to 1675 deg. fahr.
2—Quench from box in oil
3—Reheat to 1325 to 1425 deg. fahr.
4—Quench in oil
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3215-*III and* 3220-*III*

1—Carburize at 1625 to 1675 deg. fahr.
2—Quench from box in oil
3—Reheat to 1525 to 1575 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench in oil.
7—Draw at 250 to 500 deg. fahr. is recommended

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50-2.00
Chromium	0.90-1.25

Normalized at 1625 to 1725 deg. fahr.
Quenched at 1550 to 1600 deg. fahr. in *water.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to 1½-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-in. diameter or square, this chart does not apply.

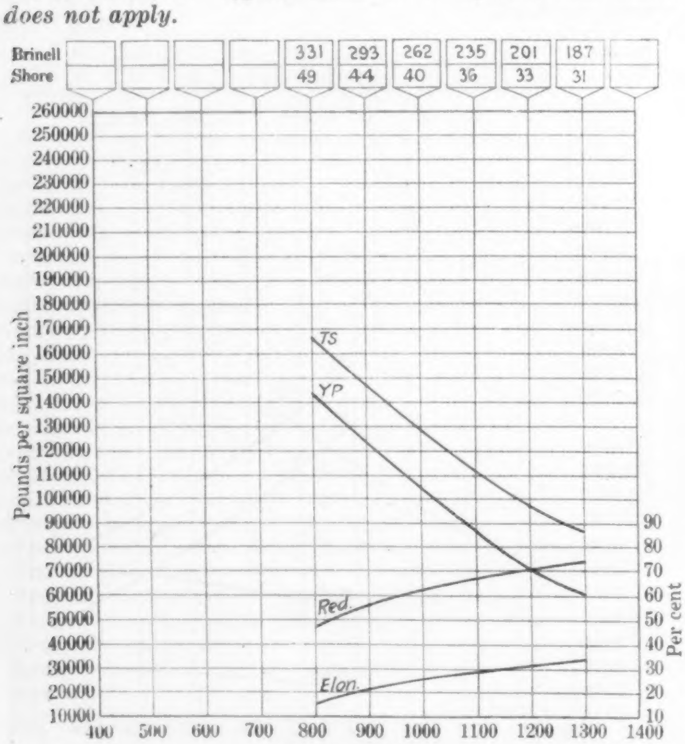


Fig. 31—Physical-Property Chart of S.A.E. Steel No. 3220 Quenched in Water

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.25-0.35
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50-2.00
Chromium	0.90-1.25

Normalized at 1625 to 1725 deg. fahr.
Quenched at 1500 to 1550 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to 1½-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-in. diameter or square, this chart does not apply.

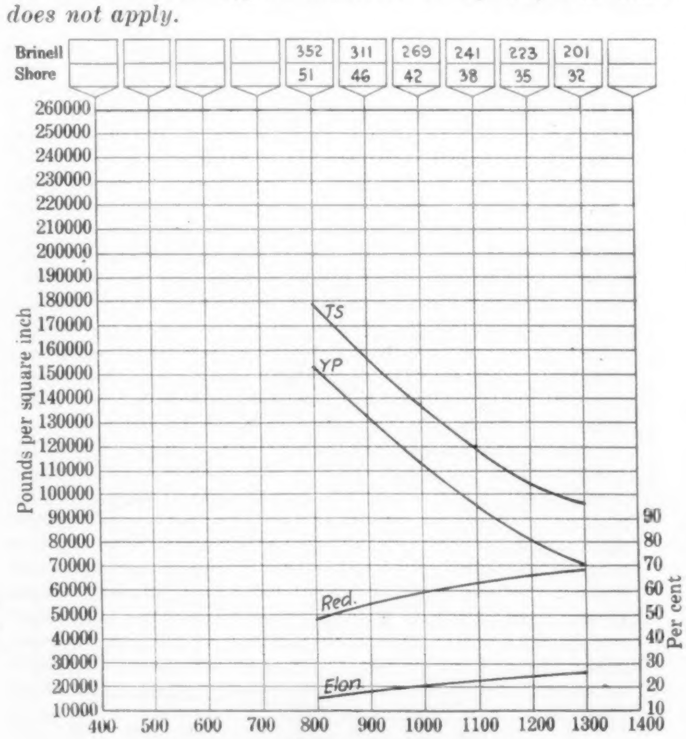


Fig. 32—Physical-Property Chart of S.A.E. Steel No. 3230 Quenched in Oil

Heat-Treatment 3215-*IV and* 3220-*IV*

1—Carburize at 1625 to 1675 deg. fahr.
2—Cool in box
3—Reheat to 1375 to 1425 deg. fahr.
4—Quench in oil
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3215-*V and* 3220-*V*

1—Carburize at 1625 to 1675 deg. fahr.
2—Cool in box
3—Reheat to 1525 to 1575 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench in oil
7—Draw at 250 to 500 deg. fahr. is recommended

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 3220-*VI*

1—Heat to 1525 to 1575 deg. fahr.
2—Quench
3—Draw to required hardness

Heat-Treatment 3220-*VII*

1—Normalize at 1625 to 1725 deg. fahr.
2—Heat to 1525 to 1575 deg. fahr.
3—Quench
4—Draw to required hardness

[For physical-property charts see Figs. 30 and 31]

S.A.E. Steel 3230

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.25-0.35
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50-2.00
Chromium	0.90-1.25

This steel is intended for heat-treated, machined and forged parts that are to be subjected to severe service conditions that demand higher physical properties than are obtainable with Steels 2330, 2335, 3125 or 3130. This steel also responds to heat-treatment more sharply and uniformly in large sections over 1½ in. in diameter than Steels 2330, 2335, 3125 or 3130.

Heat-Treatment 3230-*VI*

1—Heat to 1500 to 1550 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 3230-*VII*

1—Normalize at 1625 to 1725 deg. fahr.
2—Heat to 1500 to 1550 deg. fahr.
3—Quench in oil
4—Draw to required hardness

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

[For physical-property chart see Fig. 32]

S.A.E. Steel 3240

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.35-0.45
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50-2.00
Chromium	0.90-1.25

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.35-0.45
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50-2.00
Chromium	0.90-1.25

Normalized at 1625 to 1725 deg. fahr.
Quenched at 1475 to 1525 deg. fahr. in *oil*.

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½*-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½*-in. diameter or square, this chart does not apply.*

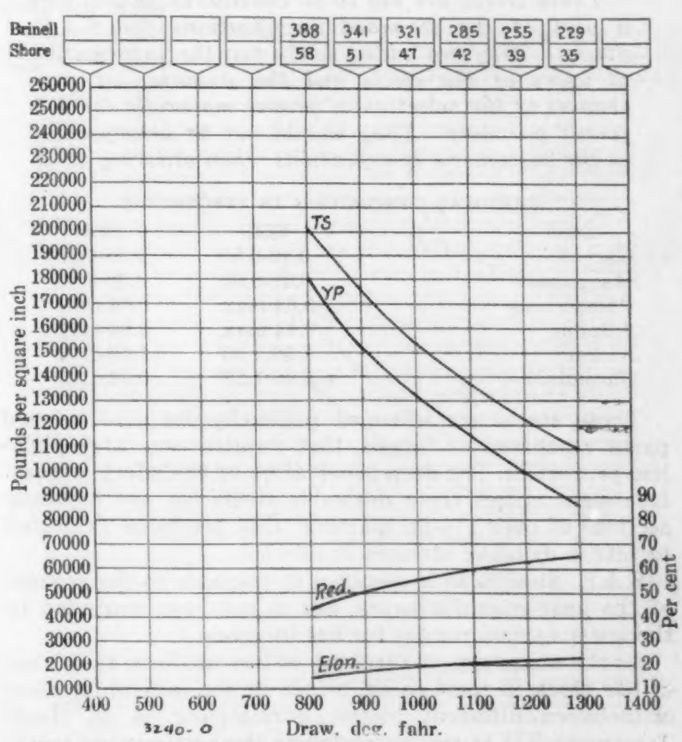


FIG. 33—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3240 QUENCHED IN OIL

This steel is intended for heat-treated forgings and machined parts that are to be subjected to service conditions demanding greater strength than is obtainable with Steels 2340, 2345, 3135 or 3140. It is also more suitable for large sections of over 1½-in. diameter than any of those steels because of the greater penetration of the effect of heat-treatment resulting from the increased chromium-content. This steel is not recommended for gears.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 3240-*VI*
1—Heat to 1475 to 1525 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 3240-*VII*
1—Normalize at 1625 to 1725 deg. fahr.
2—Reheat to 1475 to 1525 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 3240-*VIII*
1—Normalize at 1625 to 1725 deg. fahr.
2—Reheat to 1250 to 1300 deg. fahr.
3—Cool slowly
4—Machine
5—Reheat to 1450 to 1500 deg. fahr
6—Quench in oil
7—Draw to required hardness

[For physical-property chart see Fig. 33]

S.A.E. Steels 3245 *and* 3250

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	3245	3250
Carbon	0.40-0.50	0.45-0.55
Manganese	0.30-0.60	0.30-0.60
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.04 max.	0.04 max.
Nickel	1.50-2.00	1.50-2.00
Chromium	0.90-1.25	0.90-1.25

These steels are intended primarily for oil-hardened parts, machined or forged, that require very high physical properties. The deep penetration of the effect of heat-treatment makes them desirable steels for use in heavy sections of over 1½-in. diameter that are to be subjected to severe dynamic stresses in service.

S.A.E. Steel 3245 is specified in response to the request of the gear manufacturers, but is not reocommended in the lower carbon ranges for use in gears.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 3245-*VI and* 3250-*VI*
1—Heat to 1425 to 1475 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 3245-*VII and* 3250-*VII*
1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1425 to 1475 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts, such as gears, that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 3245-*VIII and* 3250-*VIII*
1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1250 to 1300 deg. fahr.
3—Cool slowly
4—Machine
5—Reheat to 1400 to 1450 deg. fahr.
6—Quench in oil
7—Draw to required hardness

[For physical-property chart see Fig. 34]

S.A.E. Steel 3312

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.17 max.
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	3.25-3.75
Chromium	1.25-1.75

Heat-Treatment 3312-*II*
1—Carburize at temperature from 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1375 to 1425 deg. fahr.
4—Quench in oil
5—Draw to 250 to 500 deg. fahr. is recommended

Heat-Treatment 3312-*III*
1—Carburize at 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1475 to 1525 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench in oil
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3312-*IV*
1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench in oil
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3312-*V*
1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1525 to 1575 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench in oil
7—Draw at 250 to 500 deg. fahr. is recommended

This steel is intended primarily for case-hardening when a core possessing very high strength and toughness is desired.

Carburized parts made from this steel may be subjected to Heat-Treatment II when hardness only is required and distortion is not important. When maximum hardness of the case and refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the core and the least possible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and the core is desired, distortion not being important, Heat-Treatment V should be used.

When this steel is used for gears for which a high degree of accuracy and strength is required, it is recommended that the carburizing operation be preceded by a normalizing treatment or a quench and draw operation, which will improve the structure and machineability and tend to reduce the distortion caused by subsequent treatments.

S.A.E. Steel 3325

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.20-0.30
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	3.25-3.75
Chromium	1.25-1.75

This steel can be used interchangeably with Steel 3230 for heat-treated, machined and forged parts that must

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.45-0.55
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50-2.00
Chromium	0.90-1.25

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1425 to 1475 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to 1½-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-in. diameter or square, this chart does not apply.

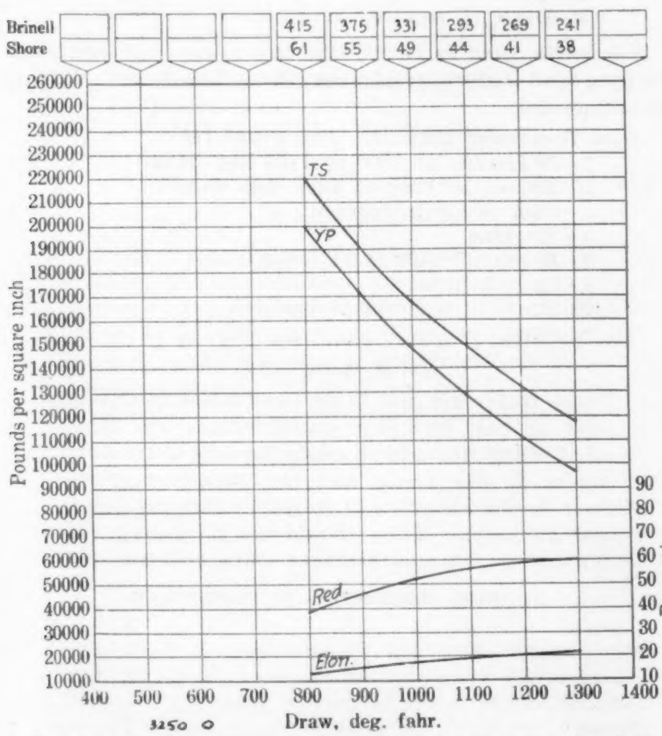


FIG. 34—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3250 QUENCHED IN OIL

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.20-0.30
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	3.25-3.75
Chromium	1.25-1.75

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1475 to 1525 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to 1½-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-in. diameter or square, this chart does not apply.

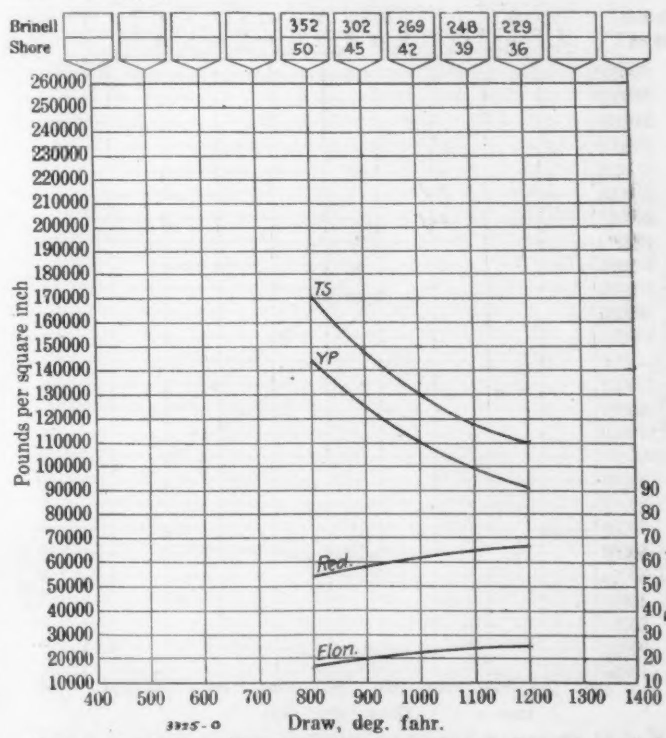


FIG. 35—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3325 QUENCHED IN OIL

possess very high physical properties and be capable of resisting severe dynamic stresses in service.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 3325-*VI*
1—Heat to 1475 to 1525 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 3325-*VII*
1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1475 to 1525 deg. fahr.
3—Quench in oil
4—Draw to required hardness

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.30-0.40
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	3.25-3.75
Chromium	1.25-1.75

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1425 to 1475 deg. fahr. in *oil*.

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to* 1½-*in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-*in. diameter or square, this chart does not apply.*

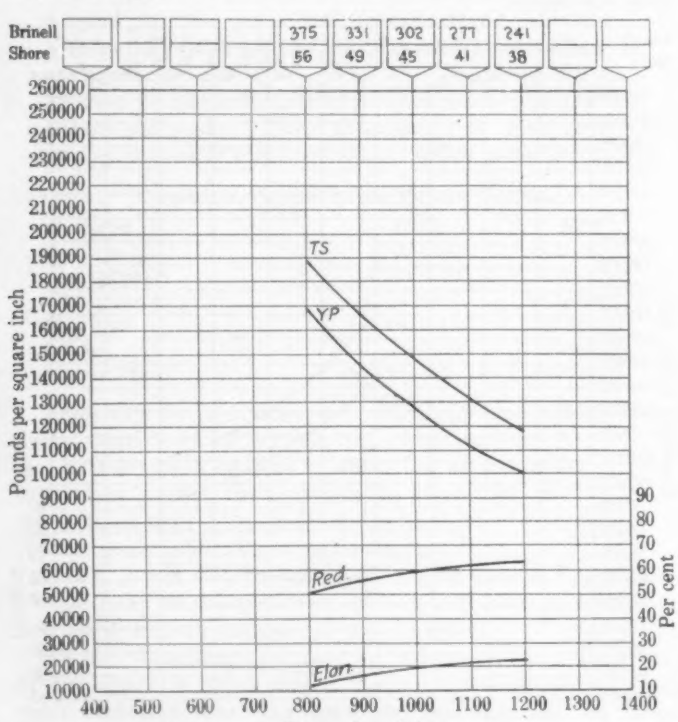


FIG. 36—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3335 QUENCHED IN OIL

For parts that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 3325-*VIII*
1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1200 to 1250 deg. fahr.
3—Cool slowly in furnace
4—Machine
5—Reheat to 1475 to 1525 deg. fahr.
6—Quench in oil
7—Draw to required hardness

[For physical-property chart see Fig. 35]

S.A.E. Steels 3335 *and* 3340

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steels	3335	3340
Carbon	0.30-0.40	0.35-0.45
Manganese	0.30-0.60	0.30-0.60
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.04 max.	0.04 max
Nickel	3.25-3.75	3.25-3.75
Chromium	1.25-1.75	1.25-1.75

These steels may be used interchangeably with Steel 3240 for such heat-treated parts, either machined or forged, as require exceptionally high physical properties and must be capable of resisting severe dynamic stresses in service.

By reason of the high alloy-content of these steels and their sensitiveness to heat-treatment, it is desirable to precede all heat-treatment operations by a normalizing treatment, as recommended in Heat-Treatment VII.

Heat-Treatment 3335-*VII and* 3340-*VII*
1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1425 to 1475 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts, such as gears, that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 3335-*VIII and* 3340-*VIII*
1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1200 to 1250 deg. fahr.
3—Cool slowly in furnace
4—Machine
5—Reheat to 1425 to 1475 deg. fahr.
6—Quench in oil
7—Draw to required hardness

[For physical-property chart see Fig. 36]

S.A.E. Steel 3415

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.10-0.20
Manganese	0.45-0.75
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	2.75-3.25
Chromium	0.60-0.95

This steel is intended primarily for case-hardening when a core possessing very high strength and toughness is desired.

When this steel is used for gears for which a high degree of accuracy and strength is required, it is recommended that the carburizing operation be preceded by a normalizing or a quench and draw operation, which will improve the structure and machineability and tend to reduce the distortion caused by subsequent treatments.

Case-hardened parts made from this steel may be subjected to Heat-Treatment II when maximum hardness only is required and distortion is not important. When maximum hardness of the case and maximum refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the case and least possible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and the core are desired, distortion not being important, Heat-Treatment V should be used.

Heat-Treatment 3415-*II*
1—Carburize at 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1375 to 1425 deg. fahr.
4—Quench in oil
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3415-*III*
1—Carburize at 1600 to 1650 deg. fahr.
2—Quench from box in oil
3—Reheat to 1500 to 1550 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench in oil
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3415-*IV*
1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1400 to 1450 deg. fahr.
4—Quench in oil
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 3415-*V*
1—Carburize at 1600 to 1650 deg. fahr.
2—Cool in box
3—Reheat to 1500 to 1550 deg. fahr.
4—Quench in oil
5—Reheat to 1375 to 1425 deg. fahr.
6—Quench in oil
7—Draw at 250 to 500 deg. fahr. is recommended

S.A.E. Steel 3435

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.30-0.40
Manganese	0.45-0.75
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	2.75-3.25
Chromium	0.60-0.95

This steel is intended for heat-treated machined and forged parts that are to be subjected to severe service conditions requiring higher physical properties than are obtainable with Steels 2330, 2335, 3125 or 3130. It also responds to heat-treatment more sharply and uniformly in large sections of over 1½-in. diameter than the steels mentioned.

By reason of the high alloy-content of this steel and its sensitiveness to heat-treatment, it is desirable to precede all heat-treatment operations by a normalizing treatment as recommended in Heat-Treatment VII.

Heat-Treatment 3435-*VII*
1—Normalize at 1550 to 1650 deg. fahr.
2—Heat to 1425 to 1475 deg. fahr.
3—Quench in oil
4—Draw to required hardness

Heat-Treatment 3435-*VIII*
1—Normalize at 1550 to 1650 deg. fahr.
2—Heat to 1250 to 1300 deg. fahr.
3—Cool slowly in furnace
4—Machine
5—Heat to 1425 to 1475 deg. fahr.
6—Quench in oil
7—Draw to required hardness

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.30-0.40
Manganese	0.45-0.75
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	2.75-3.75
Chromium	0.60-0.95

Normalized at 1550 to 1650 deg. fahr.
Quenched at 1425 to 1475 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to 1½-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-in. diameter or square, this chart does not apply.

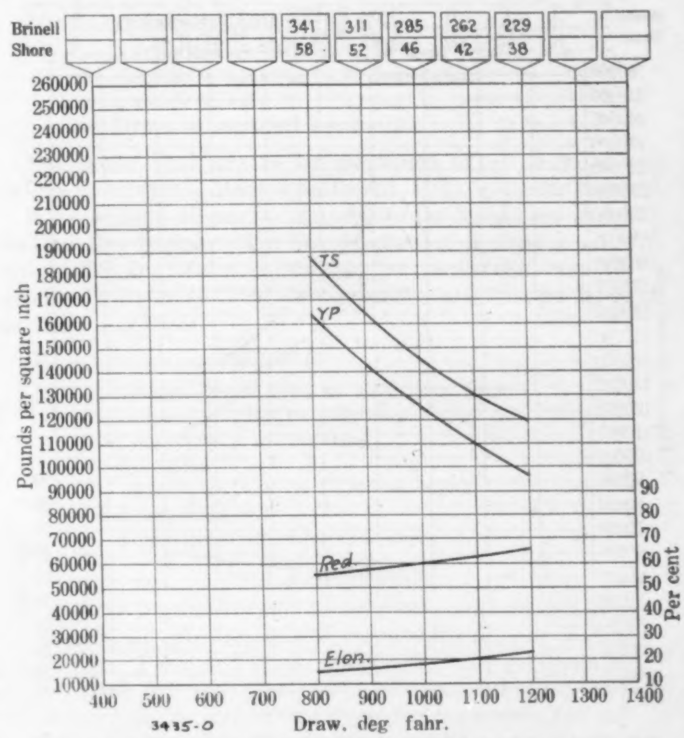


FIG. 37—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3435 QUENCHED IN OIL

For parts that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

[For physical-property chart see Fig. 37]

S.A.E. Steel 3450

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.45-0.55
Manganese	0.45-0.75
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	2.75-3.25
Chromium	0.60-0.95

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.45-0.55
Manganese	0.45-0.75
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	2.75-3.25
Chromium	0.60-0.95

Normalized at 1550 to 1650 deg. fahr.
Quenched at 1400 to 1450 deg. fahr. in *oil.*

The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to 1½-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-in. diameter or square, this chart does not apply.

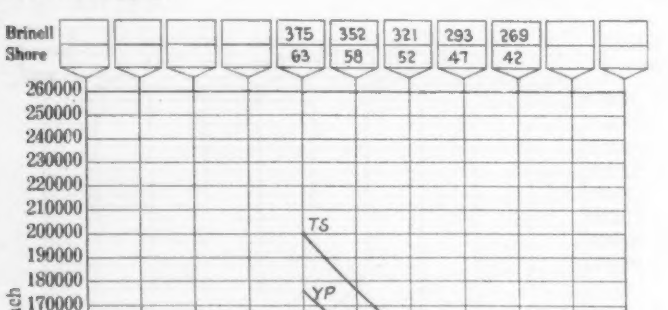


FIG. 38—PHYSICAL-PROPERTY CHART OF S.A.E. STEEL NO. 3450 QUENCHED IN OIL

This steel may be used interchangably with Steels 3240 and 3340 for such heat-treated parts, either machined or forged, as require exceptionally high physical properties and must be capable of resisting severe dynamic stresses in service.

By reason of the high alloy-content of this steel and its sensitiveness to heat-treatment, it is desirable to precede all heat-treatment operations by a normalizing treatment, as recommended in Heat-Treatment VII.

Heat-Treatment 3450-*VII*
1—Normalize at 1550 to 1650 deg. fahr.
2—Reheat to 1400 to 1450 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts, such as gears, that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 3450-*VIII*
1—Normalize at 1550 to 1650 deg. fahr.
2—Reheat to 1250 to 1300 deg. fahr.
3—Cool slowly in furnace
4—Machine
5—Reheat to 1400 to 1450 deg. fahr.
6—Quench in oil
7—Draw to required hardness

[For physical property chart see Fig. 38]

S.A.E. Steel 5120

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.30-0.60
Phosphorus	0.04 max.
Sulphur	0.045 max.
Chromium	0.60-0.90

Heat-Treatment 5120-*II*
1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box in oil
3—Reheat to 1425 to 1475 deg. fahr.
5—Draw to 250 to 500 deg. fahr. is recommended

Heat-Treatment 5120-*III*
1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box in oil
3—Reheat to 1600 to 1650 deg. fahr.
4—Quench in oil
5—Reheat to 1425 to 1475 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 5120-*IV*
1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1525 to 1575 deg. fahr.
4—Quench
5—Draw at 250 to 500 deg. fahr. is recommended

Heat-Treatment 5120-*V*
1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1600 to 1650 deg. fahr.
4—Quench in oil
4—Quench
5—Reheat to 1425 to 1475 deg. fahr.
6—Quench
7—Draw at 250 to 500 deg. fahr. is recommended

This steel is intended primarily for case-hardening.

For structural purposes the chromium-content of this steel gives a deeper penetration of the effect of heat-treatment than can be attained in a plain carbon-steel having a similar carbon-content, and the physical properties are similar to those of Steels 2320 and 3120.

When this steel is to be case-hardened for use in gears for which a high degree of accuracy and strength is required, it is recommended that the carburizing operation be preceded by normalizing at 1600 to 1700 deg. fahr., which will improve the structure and tend to reduce the distortion caused by subsequent treatments.

Case-hardened parts made from this steel may be subjected to Heat-Treatment II when maximum hardness of the case only is required and distortion is not important. When maximum hardness and maximum refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the case and the least possible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and the core is desired, distortion not being important, Heat-Treatment V should be used.

S.A.E. Steel 5140

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.35-0.45
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Chromium	0.80-1.10

This steel may be used interchangeably with Steels 2340 and 3140 for heat-treated automotive forgings requiring greater strength and toughness than are obtainable in plain carbon-steels. It also has a wider heat-treating range.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 5140-*VI*

1—Heat to 1500 to 1600 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 5140-*VII*

1—Normalize at 1625 to 1725 deg. fahr.
2—Reheat to 1500 to 1600 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

With regard to parts that are to be machined in automatics the temperature for operation 2 should not exceed 1290 deg. fahr., although for parts that are to be machined in lathes, the temperature may range as high as 1400 deg. fahr.

Heat-Treatment 5140-*VIII*

1—Normalize at 1625 to 1725 deg. fahr.
2—Reheat to 1250 to 1350 deg. fahr.
3—Cool slowly in furnace
4—Machine
5—Reheat to 1500 to 1600 deg. fahr.
6—Quench in oil
7—Draw to required hardness

S.A.E. Steel 5150

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.45-0.55
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Chromium	0.80-1.10

This is an oil-hardening type of steel intended for heat-treated automotive forgings that require greater strength and toughness than are obtainable with plain carbon-steels or with some of the simple alloy-steels having a lower carbon-content. It also has a wider heat-treating range than the other simple alloy-steels.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 5150-*VI*

1—Heat to 1450 to 1550 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 5150-*VII*

1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1450 to 1550 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

With regard to parts that are to be machined in automatics the temperature for operation 2 should not exceed 1290 deg. fahr., although for parts that are to be machined in lathes, the temperature may range as high as 1400 deg. fahr.

Heat-Treatment 5150-*VIII*

1—Normalize at 1600 to 1700 deg. fahr.
2—Reheat to 1250 to 1350 deg. fahr.
3—Cool slowly in furnace
4—Machine
5—Reheat to 1450 to 1550 deg. fahr.
6—Quench in oil
7—Draw to required hardness

S.A.E. Steel 52100

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.95-1.10
Manganese	0.20-0.50
Phosphorus	0.03 max.
Sulphur	0.03 max.
Chromium	1.20-1.50

This steel is used chiefly for the races and balls or rollers of anti-friction bearings.

The chromium and carbon-contents cause a maximum penetration of the effect of heat-treatment and develop a high degree of hardness.

For all general applications when a normalized and annealed material is to be handled, Heat-Treatment VI is recommended.

Heat-Treatment 52100-*VI*
1—Heat to 1500 to 1550 deg. fahr.
2—Quench in oil
3—Draw to required hardness

When the user forges or hot-presses parts to shape, a special treatment must precede all machining operations.

Heat-Treatment 52100 *Special*
1—Heat to 1650 to 1750 deg. fahr.
2—Cool to 1000 deg. fahr., black heat, by opening furnace
3—Reheat to 1300 to 1350 deg. fahr. and hold for at least 36 hr. or until the desired structure and machinability are obtained. Then cool slowly in furnace
4—Machine
5—Reheat to 1500 to 1550 deg. fahr.
6—Quench in oil
7—Draw to required hardness

S.A.E. Steel 6120

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.15-0.25
Manganese	0.50-0.80
Phosphorus	0.04 max.
Sulphur	0.04 max.
Chromium	0.80-1.10
Vanadium	0.15 min. 0.18 desired

This steel is intended primarily for case-hardening and can be used interchangeably with Steels 2315, 2320, 3115 and 3120 for such purpose. It can also be used for structural parts after suitable heat-treatment.

Carburized parts made from this steel may be subjected to Heat-Treatment II when hardness only is required and distortion is not important. When maximum hardness of the case and maximum refinement of both the case and the core are desired, distortion again being unimportant, Heat-Treatment III should be used. When hardness, refinement of the case and the least poossible distortion are required, Heat-Treatment IV should be used. When refinement of both the case and the core is desired, distortion not being important, Heat-Treatment V should be used.

When this steel is used for gears for which a high degree of accuracy and strength is required, it is recommended that the carburizing operation be preceded by normalizing at 1650 to 1750 deg. fahr., which will improve the structure and tend to reduce the distortion caused by subsequent treatments.

Heat-Treatment 6120-*II*
1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box in oil
3—Reheat to 1425 to 1475 deg. fahr.
4—Quench
5—Draw to 250 to 500 deg. fahr. is recommended

Heat-Treatment 6120-*III*
1—Carburize at 1650 to 1700 deg. fahr.
2—Quench from box in oil
3—Reheat to 1600 to 1650 deg. fahr.
4—Quench in oil
5—Reheat to 1425 to 1475 deg. fahr.
6—Quench
7—Draw to 250 to 500 deg. fahr. is recommended

Heat-Treatment 6120-*IV*
1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1525 to 1575 deg. fahr.
4—Quench
5—Draw to 250 to 500 deg. fahr. is recommended

Heat-Treatment 6120-*V*
1—Carburize at 1650 to 1700 deg. fahr.
2—Cool in box
3—Reheat to 1600 to 1650 deg. fahr.
4—Quench in oil
5—Reheat to 1425 to 1475 deg. fahr.
6—Quench
7—Draw to 250 to 500 deg. fahr. is recommended

S.A.E. Steels 6125 *and* 6130

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	6125	6130
Carbon	0.20-0.30	0.25-0.35
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.04 max	0.04 max.
Sulphur	0.04 max.	0.04 max.
Chromium	0.80-1.10	0.80-1.10
Vanadium	0.15 min. 0.18 desired	0.15 min. 0.18 desired

This steel can be used interchangeably with Steels 2330, 2335, 3125, 3130 and 3325 for heat-treated automotive forgings requiring greater strength and toughness than are obtainable with plain carbon-steel.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 6125-*VI and* 6130-*VI*
1—Heat to 1575 to 1675 deg. fahr.
2—Quench
3—Draw to required hardness

Heat-Treatment 6125-*VII and* 6130-*VII*
1—Normalize at 1650 to 1750 deg. fahr.
2—Reheat to 1575 to 1675 deg. fahr.
3—Quench
4—Draw to required hardness

For forgings that are to be machined after heat-treating Heat-Treatment VII is recommended.

S.A.E. Steels 6135 and 6140

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	6135	6140
Carbon	0.30-0.40	0.35-0.45
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.04 max.	0.04 max.
Chromuim	0.80-1.10	0.80-1.10
Vanadium	0.15 min.	0.15 min.
	0.18 desired	0.19 desired

These steels can be used interchangeably with the nickel and nickel-chromium steels of similar carbon-content for heat-treated automotive forgings requiring greater strength, toughness and resistance to fatiguing conditions than it is possible to obtain with plain carbon-steel.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 6135-VI and 6140-VI

1—Heat to 1550 to 1650 deg. fahr.
2—Quench in oil
3—Draw to required hardness

For all general requirements Heat-Treatment VII is recommended.

Heat-Treatment 6135-VII and 6140-VII

1—Normalize at 1650 to 1750 deg. fahr.
2—Reheat to 1550 to 1650 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 6135-VIII and 6140-VIII

1—Normalize at 1650 to 1750 deg. fahr.
2—Reheat to 1250 to 1350 deg. fahr.
3—Cool slowly
4—Machine
5—Reheat to 1550 to 1650 deg. fahr.
6—Quench in oil
7—Draw to required hardness

S.A.E. Steels 6145 and 6150

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

These steels are intended for heat-treated forgings and machined parts that are to be subjected to service conditions requiring greater strength than is obtainable with Steels 1045 and 2345 or low-chromium-nickel steels of similar carbon-content.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	6145	6150
Carbon	0.40-0.50	0.45-0.55
Manganese	0.50-0.80	0.50-0.80
Phosphorus	0.04 max.	0.04 max.
Sulphur	0.04 max.	0.04 max.
Chromium	0.80-1.10	0.80-1.10
Vanadium	0.15 min.	0.15 min.
	0.18 desired	0.19 desired

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 6145-VI and 6150-VI

1—Heat to 1525 to 1625 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 6145-VII and 6150-VII

1—Normalize at 1650 to 1750 deg. fahr.
2—Reheat to 1525 to 1625 deg. fahr.
3—Quench in oil
4—Draw to required hardness

For parts, such as gears, that are to be machined after forging and before treatment, Heat-Treatment VIII is recommended.

Heat-Treatment 6145-VIII and 6150-VIII

1—Normalize at 1650 to 1750 deg. fahr.
2—Reheat to 1250 to 1350 deg. fahr.
3—Cool slowly
4—Machine
5—Reheat to 1525 to 1625 deg. fahr.
6—Quench in oil
7—Draw to required hardness

S.A.E. Steel 6195

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.90-1.05
Manganese	0.20-0.45
Phosphorus	0.03 max.
Sulphur	0.03 max.
Chromium	0.80-1.10
Vanadium	0.15 min.
	0.18 desired

Heat-Treatment 6195-VI

1—Heat to 1500 to 1550 deg. fahr.
2—Quench in oil
3—Draw to required hardness

Heat-Treatment 6195 Special

1—Heat to 1650 to 1750 deg. fahr.
2—Cool to 1000 deg. fahr., black heat, by opening furnace
3—Reheat to 1300 to 1350 deg. fahr. and hold for at least 36 hr. or until the desired structure and machinability are obtained. Then cool slowly in furnace
4—Machine
5—Reheat to 1500 to 1550 deg. fahr.
6—Quench in oil
7—Draw to required hardness

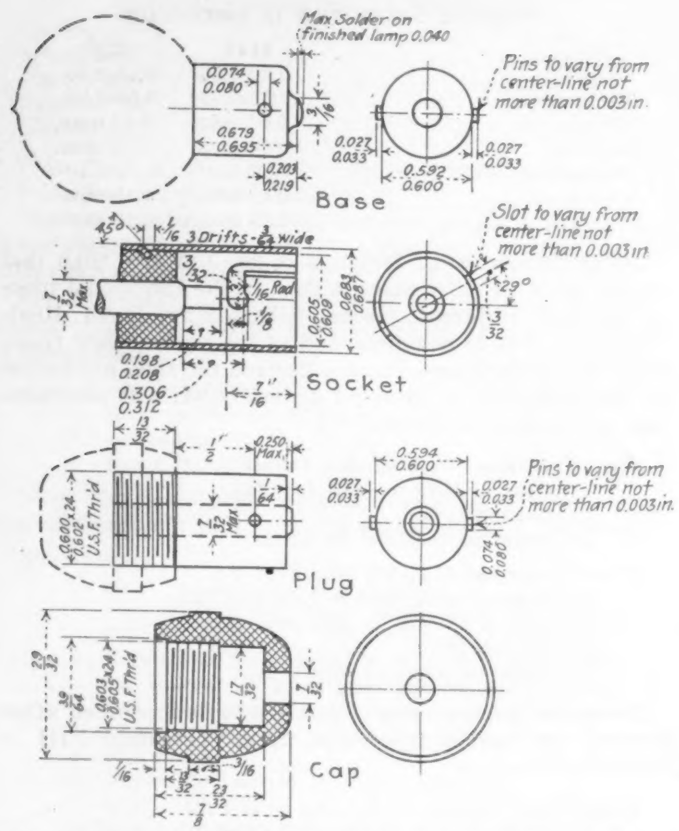


FIG. 39—ELECTRIC BASE, SOCKET, PLUG AND CAP FOR GROUND-RETURN SYSTEM

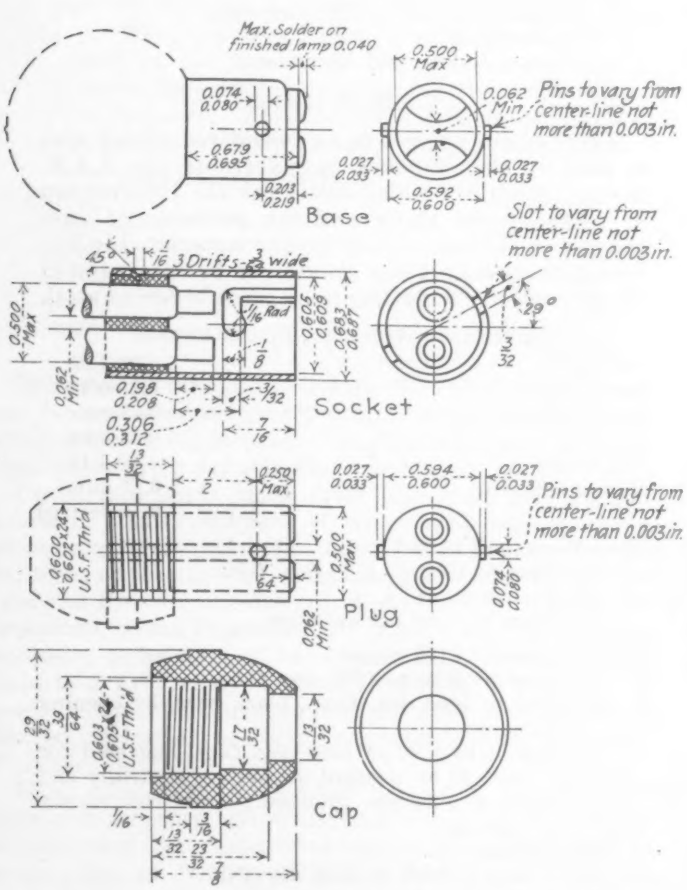


FIG. 40—ELECTRIC BASE, SOCKET, PLUG AND CAP FOR INSULATED-RETURN SYSTEM

This steel has a limited application in automotive constructions. It has some application in anti-friction bearings and is used extensively for machine-tool parts, being primarily a tool steel.

For all general applications when a normalized and annealed material is to be handled, Heat-Treatment VI is recommended.

When the user forges or hot-presses parts to shape, a special treatment must precede all machining operations.

S.A.E. Steels 9250 *and* 9260

These Notes are not to be considered in any way a part of the standard specifications for S.A.E. Steels. They are added solely for the information of users of the steels and the guidance of purchasers in the selection of proper materials for different purposes. They should not be incorporated in the customer's specifications when ordering steel.

CHEMICAL COMPOSITION IN PERCENTAGE

Steel	9250	9260
Carbon	0.45-0.55	0.55-0.65
Manganese	0.60-0.90	0.60-0.90
Phosphorus	0.045 max.	0.045 max.
Sulphur	0.045 max.	0.045 max.
Silicon	1.80-2.20	1.80-2.20

These steels have been standardized by usage principally as spring steels. They are also used to some extent for gears with Heat-Treatment VIII. Neither steel is suitable for use without heat-treatment.

As the structure of forgings is less uniform than that of bar stock in most cases, either in the individual piece or between different pieces, normalizing as in Heat-Treatment VIII is recommended as the preliminary treatment for all forgings, but the desired physical properties of bar stock can be obtained generally without normalizing, as in Heat-Treatment VI.

Heat-Treatment 9250-*VI and* 9260-*VI*

1—Heat to 1500 to 1650 deg. fahr.
2—Quench in oil
3—Draw to required hardness or tests

For gears made of this steel, Heat-Treatment VIII is recommended.

Heat-Treatment 9250-*VIII and* 9260-*VIII*

1—Normalize at 1650 to 1750 deg. fahr.
2—Reheat to 1400 to 1450 deg. fahr.
3—Cool slowly
4—Machine
5—Reheat to 1600 to 1650 deg. fahr.
6—Quench
7—Draw to required hardness or tests

LIGHTING DIVISION REPORT

BASES, SOCKETS AND CONNECTORS

(Proposed Revision of S.A.E. Standard)

Th Lighting Division recommends that the following revision of the present S.A.E. Standard for Bases, Sockets and Connectors, page B4, S.A.E. HANDBOOK, covering both the ground-return and insulated-return systems be adopted.

(1) The addition of limits of 0.306 to 0.312 in. for the distance from the end of the plunger sleeve to the top of the locking slot

(2) The elimination of limits of 0 to 1/64 in. for the distance from the top of the plunger when extended to the bottom of the locking slot

(3) The addition of a footnote referring to the locking-pins and slots of the bases, sockets and plugs, to the effect that the variation from the center-line shall not be more than 0.003 in.

This revision is recommended by the Division largely because of the relation between the distance from the top of the plunger when depressed to the top of the locking slot and the maximum distance from the top of the locking pin to the end of the solder of the finished lamp, which might in some cases result in a very tight fit of the lamp base in the socket, if the recommendations specified above were not followed. The present standard revised as proposed is given in Figs. 39 and 40.

Lamp Glasses

(Proposed Revision of S.A.E. Standard)

The Lighting Division recommends that the present S.A.E. Standard for Lamp Glasses, page B6, S.A.E. HANDBOOK, be extended to specify the dimensions of the locking notches in the head-lamp glasses as shown in Fig. 41. These notches are to prevent the glass from turning in the lamp, which is a matter of importance in other than plain lamp-glasses.

The recommendation specifies the use of notches rather than projecting lugs as the latter are likely to be broken off in shipping. Four notches as illustrated are considered advisable as glasses with notches so arranged will fit the greatest number of head-lamps now in use.

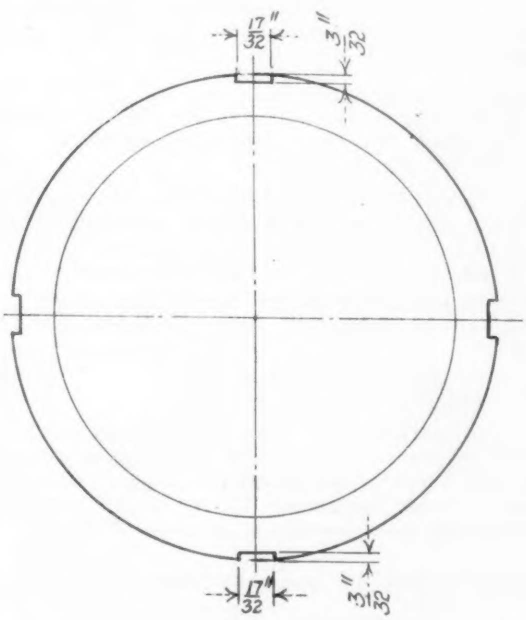
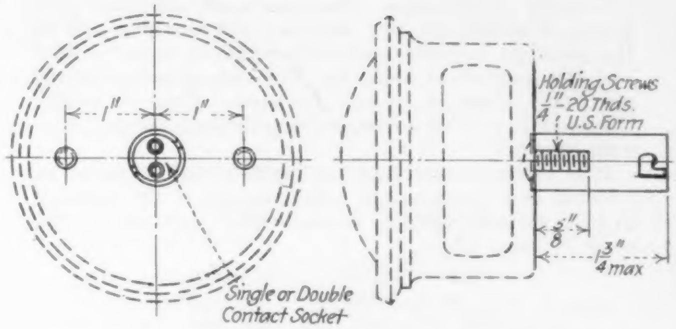


FIG. 41—PROPOSED ARRANGEMENT OF HEAD-LAMP GLASS RIM TO PREVENT THE GLASS FROM TURNING IN THE RIM

Tail-Lamps

(Proposed S.A.E. Recommended Practice)

The Lighting Division recommends the adoption as S.A.E. Recommended Practice of the tail-lamp mounting-dimensions specified in Fig. 42. The adoption of these dimensions in actual practice will make tail-lamps interchangeable. Lamp dimensions are not specified so as not to limit individuality in design, the important features being the size and location of the mounting studs and the location and maximum projection of the connector. Reduction of the recommendation to practice will eliminate the many different methods of mounting now used and provide for definite clearances and arrangements of electrical connections, thus lessening the cost of manufacturing.



HOLDING SCREWS: Two $\frac{1}{4}$ in.-20 U.S. Form threads $\frac{5}{8}$ in. long

TAIL-LAMP GLASS DIAMETER: 3 in. plus 0, minus $\frac{1}{32}$ in.

FIG. 42—TAIL-LAMP OVERALL DIMENSIONS AND MOUNTING SCREWS

NON-FERROUS METALS DIVISION REPORT

Non-Ferrous Metal Specifications

(Proposed Revision of S.A.E. Standard)

At the meeting of the Standards Committee and the Society held last January the Non-Ferrous Metals Division reported a revised and considerably extended list of S.A.E. Non-Ferrous Metal Specifications. As the list is not as complete as desired, the Division has done a large amount of work during the past year with a view to adding to it, as well as revising some of the specifications. The new and revised specifications have been reviewed carefully and wherever possible made to conform with those of the American Society for Testing Materials. The revisions proposed are in accordance with most acceptable current practice and were prepared by Subdivisions representing the respective branches of the non-ferrous metal industries.

SPECIFICATION NO. 1—SOLDER

COMPOSITION IN PERCENTAGE

	Class A	Class B
Tin, minimum	49.50	48.75
Tin, maximum	50.50	49.75
Lead, approximate	50.00	50.00
Antimony, maximum	0.12	0.75
Copper, maximum	0.08	0.15
Zinc and Aluminum	None	None
Other Impurities, maximum	0.10	0.10

General Information The choice of the class and grade of solder for any specified purpose depends on the material in connection with which it is to be used and the method of applying. For galvanized iron and zinc, only Class A should be used. Class A solder should be furnished under this specification unless otherwise specified.

It is recommended that the grade of solder metal be selected that contains the least amount of tin required to give suitable flowing and adhesive qualities for the work in hand.

	Melting Point, deg. cent.	Melting Point, deg. fahr.	Complete Liquation Point, deg. cent.	Complete Liquation Point, deg. fahr.
Class A	181.0	357.8	213.0	415.4
Class B	185.0	365.0	208.0	397.4

SPECIFICATION NO. 2—SOLDER

COMPOSITION IN PERCENTAGE

	Class A	Class B
Tin, minimum	44.50	43.00
Tin, maximum	45.50	44.00
Lead, approximate	55.00	55.00
Antimony, maximum	0.12	1.50
Copper, maximum	0.08	0.15
Zinc and Aluminum	None	None
Other Impurities, maximum	0.10	0.10

General Information The choice of the class and grade of solder for any specified purpose depends on the material in connection with which it is to be used and the method of applying. For galvanized iron and zinc, only Class A should be used. Class A solder should be furnished under this specification unless otherwise specified.

It is recommended that the grade of solder metal be selected that contains the least amount of tin required to give suitable flowing and adhesive qualities for the work in hand.

	Melting Point,		Complete Liquation Point,	
	deg. cent.	deg. fahr.	deg. cent.	deg. fahr.
Class A	181	357.8	225	437.0
Class B	188	370.4	220	428.0

SPECIFICATION NO. 3—SOLDER

COMPOSITION IN PERCENTAGE

	Class A	Class B
Tin, minimum	39.60	37.60
Tin, maximum	40.40	38.40
Lead, approximate	60.00	60.00
Antimony, maximum	0.12	2.00
Copper, maximum	0.08	0.15
Zinc and Aluminum	None	None
Other Impurities, maximum	0.10	0.10

General Information The choice of the class and grade of solder for any specified purpose depends on the material in connection with which it is to be used and the method of applying. For galvanized iron and zinc, only Class A should be used. Class A solder should be furnished under this specification unless otherwise specified.

It is recommended that the grade of solder metal be selected that contains the least amount of tin required to give suitable flowing and adhesive qualities for the work in hand.

	Melting Point,		Complete Liquation Point,	
	deg. cent.	deg. fahr.	deg. cent.	deg. fahr.
Class A	181	357.8	237	458.6
Class B	188	370.4	228	442.4

SPECIFICATION NO. 4—SOLDER

COMPOSITION IN PERCENTAGE

	Class A	Class B
Tin, minimum	24.50	22.50
Tin, maximum	25.50	23.50
Lead, approximate	75.00	75.00
Antimony, maximum	0.12	2.00
Copper, maximum	0.08	0.15
Zinc and Aluminum	None	None
Other Impurities, maximum	0.10	0.10

General Information This solder is recommended for use on work that is to be coated with enamel and then baked as it will withstand higher baking temperatures than solders containing larger amounts of tin.

The choice of the class and grade of solder for any specified purpose depends on the material in connection with which it is to be used and the method of applying. For galvanized iron and zinc, only Class A should be used. Class A solder should be furnished under this specification unless otherwise specified.

It is recommended that the grade of solder metal be selected that contains the least amount of tin required to give suitable flowing and adhesive qualities for the work in hand.

	Melting Point,		Complete Liquation Point,	
	deg. cent.	deg. fahr.	deg. cent.	deg. fahr.
Class A	181	357.8	268	514.5
Class B	188	370.4	258	496.5

SPECIFICATION NO. 14—BABBITT

COMPOSITION IN PERCENTAGE

Tin, minimum	9.25
Tin, maximum	10.75
Antimony, minimum	14.00
Antimony, maximum	16.00
Lead, minimum	74.00
Lead, maximum	76.00
Copper, maximum	0.50
Iron	None
Arsenic, maximum	0.20
Zinc	None
Aluminum	None

General Information This is a cheap babbitt and serves successfully where the bearings are large and the service light. It should not be used as a substitute for a babbitt with a high tin-content. It is also suitable for die-castings.

SPECIFICATION NO. 43—MANGANESE BRONZE

COMPOSITION IN PERCENTAGE

Copper, minimum	53.00
Copper, maximum	62.00
Zinc, minimum	38.00
Zinc, maximum	47.00
Lead, maximum	0.15

This metal may be hardened by the addition of small amounts of tin, iron, manganese, aluminum, or a combination of these metals. Good sand castings made of this alloy should give the following minima in physical characteristics.

Tensile-Strength, lb. per sq. in.	60,000
Yield-Point, lb. per sq. in.	30,000
Elongation in 2 In. or Proportionate Gage-Length, per cent	15

For the purpose of inspection, the most importance should be placed on the following minima in physical requirements on a special chill cast ½-in. test-bar. This test-bar shall be cut from one corner, near the bottom of the test ingot, cast in a properly tapered iron mold, approximately 3 in. deep by 2¾ in. wide by 12 in. long.

Tensile-Strength, lb. per sq. in.	70,000
Elongation in 2 In., per cent	20

General Information This alloy is intended for use in castings where strength and toughness are required. It is equivalent to the copper-zinc alloys commercially known as cast manganese bronze or its equivalents, such as cast tobin bronze and cast naval bronze.

SPECIFICATION NO. 44—CAST BRASS TO BE BRAZED

COMPOSITION IN PERCENTAGE

Copper, minimum	83.00
Copper, maximum	86.00
Zinc, minimum	14.00
Zinc, maximum	17.00
Lead, maximum	0.50
Iron, maximum	0.15

General Information This brass starts to melt at approximately 1830 deg. fahr. and is entirely melted at approximately 1870 deg. fahr. As a brazing material on this brass to be brazed either Silver Solder or a brazing brass melting at a temperature lower than the brass to be brazed should be used.

SPECIFICATION NO. 45—BRAZING SOLDER

COMPOSITION IN PERCENTAGE

Copper, minimum	48.00
Copper, maximum	52.00
Lead, maximum	0.50
Iron, maximum	0.10
Zinc	Remainder

General Information This solder starts to melt at approximately 1560 deg. fahr. and is entirely melted at approximately 1600 deg. fahr. It may be used by melting it in a crucible under a flux of borax, with or without the addition of boric acid, and dipping the material to be brazed in the melted brazing solder; or this brazing solder, in a powdered form, may be mixed with the flux applied to the material to be brazed, and melted either in a furnace or by the use of a brazing torch.

SPECIFICATION NO. 70—COMMERCIAL BRASS SHEET

COMPOSITION IN PERCENTAGE

Copper, minimum	64.50
Copper, maximum	67.50
Lead, maximum	0.30
Iron, maximum	0.05
Other Impurities, maximum	0.10
Zinc	Remainder

MECHANICAL REQUIREMENTS

Temper and Anneal.—The temper of the sheet brass shall be designated as follows:

	Reduction, B. & S. Gage Nos.
Quarter Hard	1
Half Hard	2
Hard	4
Extra Hard	6
Spring	8

The annealed sheet shall be designated as Light Anneal, Drawing Anneal or Soft Drawing Anneal.

The average Brinell hardness of 10 samples of sheet 0.080 in. or over in thickness shall be within the following limits:

Quarter Hard	75 to 95
Half Hard	95 to 115
Hard	130 to 150
Extra Hard	150 to 170
Spring	160 to 180
Light Anneal	65 to 75
Drawing Anneal	55 to 65
Soft Drawing Anneal	47 to 55

The average of tension tests of two samples of sheet thinner than 0.080 in. shall conform to the following minimum requirements:

Temper	Tensile-Strength, lb., per sq. in.	Elongation in 2 In., per cent.
Quarter Hard	45,000	27.5
Half Hard	52,500	15.0
Hard	67,500	5.0
Extra Hard	80,000	2.0
Spring	87,500	1.0
Light Anneal	45,000	32.0
Drawing Anneal	42,000	38.0
Soft Drawing Anneal	40,000	42.0

In very thin strips, on account of the difficulties in testing, the elongation may be considerably less than the figures given.

PERMISSIBLE VARIATIONS IN THICKNESS, IN.

Thickness, B. & S. Gage No.		Thickness, in.		Width, in.			
From	To	From	To	Up to 5, Inclusive	Over 5, to 8, Inclusive	Over 8, to 11, Inclusive	Over 11, to 14, Inclusive
0000	0	0.4600	0.3248	±0.0044	±0.0048	±0.0051	±0.0055
Below 0	4	0.3248	0.2043	±0.0039	±0.0043	±0.0046	±0.0050
4	8	0.2043	0.1284	±0.0034	±0.0038	±0.0041	±0.0045
8	14	0.1284	0.0640	±0.0029	±0.0033	±0.0036	±0.0040
14	18	0.0640	0.0403	±0.0025	±0.0029	±0.0033	±0.0037
18	24	0.0403	0.0201	±0.0020	±0.0024	±0.0028	±0.0032
24	28	0.0201	0.0126	±0.0016	±0.0020	±0.0024	±0.0028
28	32	0.0126	0.0079	±0.0013	±0.0017	±0.0020	±0.0024
32	35	0.0079	0.0056	±0.0010	±0.0014	±0.0017	±0.0022
35	38 Incl.	0.0056	0.0039	±0.0008	±0.0012	±0.0015	±0.0019

These should be considered as general specifications. Since high brass is used for many purposes where the requirements of the operations used are too particular to be specified by any of the ordinary physical tests, it is frequently advisable to submit samples or drawings to the manufacturer and secure an adjustment of anneal or temper to suit the actual operations to which the material is to be submitted.

SPECIFICATION NO. 71—COPPER SHEET

COMPOSITION IN PERCENTAGE

Copper, minimum	99.50

MECHANICAL REQUIREMENTS

TENSILE-STRENGTH AND ELONGATION, SOFT COPPER

Thickness, in.	Tensile-Strength, maximum, lb. per sq. in.	Elongation in 2 In., minimum, per cent
0.005 to 0.031	37,000	20.0
0.032 to 0.375	36,000	25.0

TENSILE-STRENGTH AND ELONGATION, HARD COPPER

Thickness, in.	Tensile-Strength, minimum, lb. per sq. in.	Elongation in 2 In., minimum, per cent
Less than .072	As hard as possible to stand bending cold through an angle of 180 deg. flat back without fracture on the outside of the bent portion.	
0.072 to 0.375	40,000	8.0
over 0.375	35,000	15.0

PERMISSIBLE VARIATIONS IN THICKNESS, IN.

Thickness, B. & S. Gage No.		Thickness, in.		Width, in.			
From	To	From	To	Up to 5, Inclusive	Over 5, to 8, Inclusive	Over 8, to 11, Inclusive	Over 11, to 14, Inclusive
0000	0	0.4600	0.3248	±0.0044	±0.0048	±0.0051	±0.0055
Below 0	4	0.3248	0.2043	±0.0039	±0.0043	±0.0046	±0.0050
4	8	0.2043	0.1284	±0.0034	±0.0038	±0.0041	±0.0045
8	14	0.1284	0.0640	±0.0029	±0.0033	±0.0036	±0.0040
14	18	0.0640	0.0403	±0.0025	±0.0029	±0.0033	±0.0037
18	24	0.0403	0.0201	±0.0020	±0.0024	±0.0028	±0.0032
24	28	0.0201	0.0126	±0.0016	±0.0020	±0.0024	±0.0028
28	32	0.0126	0.0079	±0.0013	±0.0017	±0.0020	±0.0024
32	35	0.0079	0.0056	±0.0010	±0.0014	±0.0017	±0.0022
35	38 Incl.	0.0056	0.0039	±0.0008	±0.0012	±0.0015	±0.0019

SPECIFICATION NO. 73—NAVAL BRASS (TOBIN BRONZE) ROD

COMPOSITION IN PERCENTAGE

Copper, minimum	59.00
Copper, maximum	62.00
Tin, minimum	0.50
Tin, maximum	1.50
Iron, maximum	0.10
Lead, maximum	0.30
Other Impurities, maximum	0.10
Zinc	Remainder

MECHANICAL REQUIREMENTS

TENSILE-TEST DATA

Diameter or Thickness, in.		Minimum Tensile -Strength, lb. per sq. in.	Minimum Yield -Point, lb. per sq. in.	Minimum Elongation in 2 In., per cent.
Over	To and Including			
0	1	62,000	31,000	25.0
1	2½	60,000	30,000	30.0
2½	3½	56,000	25,000	35.0
3½		54,000	22,000	40.0

Strain Test A full-size test-specimen must stand immersion for 15 min. without cracking in an aqueous

solution containing 100 grams of mercurous nitrate and 13 cc. of nitric acid of specific gravity 1.42 per liter.

Bend Test The rods shall stand cold-bending without fracture through an angle of 120 deg. around a pin, the radius of which is equal to the diameter or thickness of the rod or bar.

Dimensions and Tolerances The diameter of round sections shall not vary from that specified by more than the tolerances specified in the following table:

Diameter, in.		Tolerances, in.
Over	To and Including	
0	½	±0.0015
½	1	±0.0020
1	2½	±0.0025
2½		±0.0030

In case of other than round sections the distance between parallel faces shall be permitted to vary, in their respective sizes, double the amount of the above tolerances.

General Information This material is intended for use wherever brass rod that is stronger, tougher, and less corrodible than commercial brass rod is required.

SPECIFICATION NO. 76—NAVAL BRASS (TOBIN BRONZE) TUBING

COMPOSITION IN PERCENTAGE

Copper, minimum	59.00
Copper, maximum	62.00
Tin, minimum	0.50
Tin, maximum	1.50
Iron, maximum	0.10
Lead, maximum	0.30
Other Impurities, maximum	0.10
Zinc	Remainder

MECHANICAL REQUIREMENTS

TENSILE-TEST DATA

Thickness of Wall, in.		Minimum Tensile-Strength, lb. per sq. in.	Minimum Yield-Point, lb. per sq. in.	Minimum Elongation in 2 In., per cent
Over	To and Including			
0	⅛	60,000	24,000	28
⅛	¼	55,000	22,000	32
¼		50,000	20,000	35

DIMENSIONAL TOLERANCES

Outside Diameter, in.		Tolerances,[12] in.	Wall Thickness, in.		Tolerances,[13] in.
Over	To		Over	To	
½	¾	±0.0025	1/64	1/32	±0.0020
¾	1	±0.0030	1/32	1/16	±0.0030
1	1¼	±0.0035	1/16	⅛	±0.0050
1¼	1½	±0.0040	⅛	¼	±0.0080
1½	1¾	±0.0045	¼	5/16	±0.0125
1¾	2	±0.0050	5/16	⅜	±0.0150
2		±0.0025 xDiam.			

[12] Either inside or outside diameter.

[13] No combination of variations on the same tube shall make the thickness of the wall vary from the nominal by more than these amounts.

Expanding Test A pin having a taper of 1 to 8 shall be driven into one end of a tube until the diameter is increased 15 per cent. The tube shall withstand this test without showing cracks, splits or other defects.

Appearance These tubes shall be clean, smooth and free from injurious defects, both inside and outside.

Special Limits On all stock where the above commercial variations are not permissible, the limits shall be specified in the order.

SPECIFICATION NO. 80—BRASS SPRING WIRE

COMPOSITION IN PERCENTAGE

	Grade A	Grade B
Copper, minimum	70.00	64.00
Copper, maximum	74.00	68.00
Lead, maximum	0.10	0.10
Iron, maximum	0.06	0.07
Zinc	Remainder	Remainder

Physical Properties This wire shall have a tensile-strength of at least 100,000 lb. per sq. in., but should be capable of being bent through an angle of 180 deg. around a wire of the same diameter without breaking.

Appearance The wire shall be uniform in quality and temper, cylindrical in shape and smooth and free from injurious defects.

Grade A is for use where the requirements are especially severe. Grade B is for use under ordinary conditions, and will be furnished unless otherwise specified.

Dimensional Tolerances.—The wire shall not vary from the specified diameter by more than plus or minus 1 per cent for sizes larger than 0.050 in.

From 0.050 to 0.025 in. the variation in size shall not be more than plus or minus 0.0005 in.

For sizes smaller than 0.025 in. the variation shall not be more than plus or minus 0.00025 in.

SPECIFICATION NO. 81—PHOSPHOR BRONZE SPRING WIRE

COMPOSITION IN PERCENTAGE

Tin, minimum	4.00
Tin, maximum	6.00
Phosphorus, minimum	0.03
Phosphorus, maximum	0.40
Zinc, maximum	0.20
Iron, maximum	0.10
Lead, maximum	0.10
Copper	Remainder

MECHANICAL REQUIREMENTS

Wire Diameter, in.	Minimum Tensile-Strength lb. per sq. in.
Up to and including 0.0625	130,000
Above 0.0625 to and including 0.1250	120,000
Above 0.1250 to and including 0.2500	110,000
Above 0.2500 to and including 0.3750	100,000

Bend Test The wire shall be capable of being bent through an angle of 180 deg. flat back on itself without fracture on the outside of the bent portion.

Appearance The wire shall be uniform in quality and temper, cylindrical in shape and smooth and free from injurious defects.

Dimensional Tolerances The wire shall not vary from the specified diameter by more than plus or minus 1 per cent for sizes larger than 0.050 in.

From 0.050 to 0.025 in. the variation in size shall not be more than plus or minus 0.0005 in.

For sizes smaller than 0.025 in. the variation shall not be more than plus or minus 0.00025 in.

SPECIFICATION NO. 88—BRASS FORGING ROD

MECHANICAL REQUIREMENTS

Flattening Test Specimens cut from rods or bars and having a length equal to the diameter of the specimen, shall stand flattening in a axial direction while hot,

until reduced to 20 per cent of their original length, without cracking.

COMPOSITION IN PERCENTAGE

Copper, minimum	58.50
Copper, maximum	61.50
Lead, minimum	1.50
Lead, maximum	2.50
Iron, maximum	0.15
Materials other than Copper, Lead and Zinc, maximum	0.35
Zinc	Remainder

When the sample is taken from several bars or rods, for analysis, it should meet this specification. If only one rod or bar is sampled, the following composition in percentage will be acceptable.

Copper	57.9 to 62.1
Lead	1.2 to 3.0

Dimensions and Tolerances The diameter of the round sections shall not vary from that specified by more than the tolerances specified in the following table:

Diameter, in.		Tolerances, in.
Over	To and Including	
0	½	±0.005
½	1	±0.008
1	2½	±0.010
2½		±0.015

General Information These specifications cover brass rods of any specified cross-section capable of being readily forged while hot and easily machined.

The rods may be manufactured either by hot-rolling or extrusion, and may be finished by cold-drawing if necessary to meet the requirements for size.

PARTS AND FITTINGS DIVISION REPORT

ROD-ENDS

(Proposed Revision of S.A.E. Standard)

Definite diameters of the pin-boss on the adjustable and plain yoke-ends have never been incorporated in the S.A.E. Standard for Rod-Ends, page C8, S.A.E. HANDBOOK. As doubt has arisen at times as to what these diameters should be, the Parts and Fittings Division has communicated with the forging and automobile manufacturers to check present practice and to obtain approval of the additions and revisions of the existing standard recommended. It is believed that the recommendations will be entirely acceptable to all the manufacturers and it is therefore recommended that the following be incorporated in the present S.A.E. Standard

(1) Specify dimension *K* as the diameter of the pin-bosses on the drawings for the adjustable and plain yoke-rod-ends, the same as now specified for the pin-boss of the eye-rod-end

(2) Change dimension *K* in the table for the ⅞-in. size from 1-13/16 to 1-11/16 in.

TAPER FITTING FOR PLAIN OR SLOTTED NUTS

(Proposed Extension of S.A.E. Standard)

The Parts and Fittings Division recommends that the present S.A.E. Standard for Taper Fittings with Plain or Slotted Nuts, page C14, S.A.E. HANDBOOK, be revised by the addition of a footnote reading

> The center-line of the cotter-pin hole shall be 90 deg. from the position of the keyway as shown on the drawing.

The Division makes this recommendation to establish definitely the location of the cotter-pin hole with respect to the position of the keyway in taper fittings, inasmuch as the hole is sometimes specified in line with the keyway and sometimes at 90 deg. to it. Adoption of the proposed revision will unify practice.

WATER-PIPE FLANGES

(Proposed S.A.E. Recommended Practice)

The Parts and Fittings Division recommends for adoption as S.A.E. Recommended Practice the water-pipe flange dimensions specified in Table 13.

This recommendation will supersede the present S.A.E. Recommended Practice specifying that the standard two and four-bolt types of carbureter flange, page A8, S.A.E. HANDBOOK, shall be used for motorboat water-pipe flanges. The type of flange now recommended by the Division is considered satisfactory for general automotive practice, and has been approved by the members of the Motorboat Division.

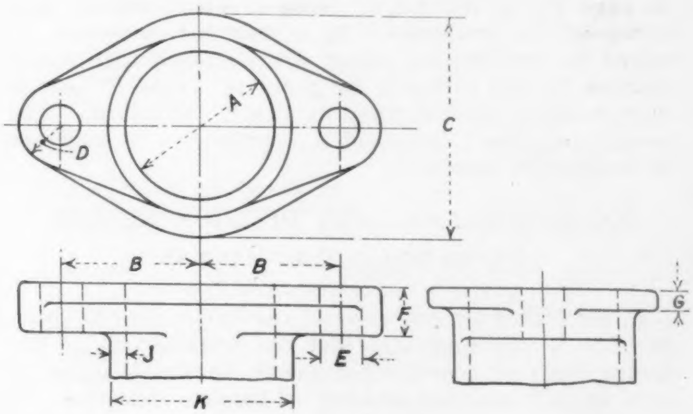


FIG. 41—WATER-PIPE FLANGES

TABLE 13—PROPOSED DIMENSIONS OF WATER-PIPE FLANGES

Nominal Flange Size, in.	1 3/16	1 7/16	1 11/16	1 15/16	2 3/16
Outside Diameter (*K*), in.	1 1/2	1 3/4	2	2 1/4	2 1/2
Inside Diameter (A), in.	1 3/16	1 7/16	1 11/16	1 15/16	2 3/16
B	1 3/16	1 11/32	1 15/32	1 21/32	1 25/32
C	1 7/8	2 3/16	2 1/2	2 13/16	3 1/8
D	11/32	13/32	13/32	15/32	15/32
E	11/32	13/32	13/32	15/32	15/32
F	13/32	15/32	15/32	9/16	9/16
G	7/32	1/4	1/4	9/32	9/32
Length,[14] in.	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2
J	5/32	5/32	5/32	5/32	5/32
Capscrews	5/16-18	3/8-16	3/8-16	7/16-14	7/16-14

[14] Length of fitting for lap of hose.

The present S.A.E. Standard for Radiators specifies that the water inlet and outlet flanges shall be the same as the S.A.E. Standard two-bolt carbureter flanges. It also specifies that such fittings shall be cast separate from the radiator tank to avoid the danger of being broken off during transportation and because in many instances the automobile manufacturers purchase these fittings from other sources than the radiator manufacturers.

The proposed outside diameters and the lengths of the fittings for the lap of hose are in accord with the S.A.E. Standard for Rubber Hose Clamps and Fittings, page C51, S.A.E. HANDBOOK.

Lock-Washers

(Proposed Revision of S.A.E. Standard)

The former Miscellaneous Division, now incorporated in the Parts and Fittings Division, considered a revision of the present S.A.E. Standard for Lock-Washers, page C5, S.A.E. Handbook, which was adopted in 1911. Developments in the automotive industry since 1911 have brought about more accurate screw-thread practice and the general use of softer metals which require lighter lock-washers. Reconsideration of the present standard was initiated by the Motorcycle Division which requested the Parts and Fittings Division to formulate a series of extra-light lock-washers for use in the motorcycle industry.

E. W. Hart, who is Chairman of the Standardization Committee of the Association of Lock Washer Manufacturers, was appointed a Subdivision to make a special study of this subject.

He submitted a tentative report which was published on page 119 of the August issue of The Journal with a request for criticisms. As a result of comments received the Subdivision report was approved with minor changes by the Division as given in Table 15 and is recommended for adoption as S.A.E. Standard. The recommendation is intended for application to all types of automotive apparatus.

PASSENGER-CAR BODY DIVISION REPORT

Passenger-Car Door Handles

(Proposed S.A.E. Recommended Practice)

At the March 1921 meeting of the Passenger-Car Body Division it was suggested that the cross-section of the square shaft of door-handles should be standardized so as to permit interchangeability of handles and locks. A Subdivision was appointed and submitted a preliminary report that was referred to passenger car and body engineers for comment. As a result of the Subdivision's report and the comments received, the Division recommends for adoption as S.A.E. Recommended Practice the door-handle squares illustrated in Figs. 42 and 43.

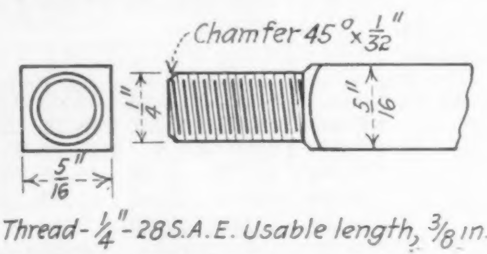


Fig. 42—Externally-Threaded Type of Door Handle Squares

The Division is of the opinion that the construction recommended is more suitable for a standard as compared with countersunk internally threaded squares because it can be more readily fitted to come flush with the door-handles when assembling. The externally threaded

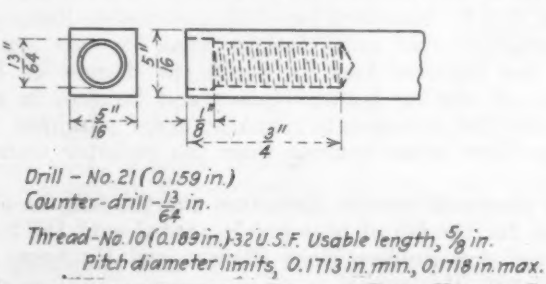


Fig. 43—Internally-Threaded Type of Door Handle Squares

type is included in the recommendation, however, for those who prefer this type of construction.

Some criticisms of the Subdivision's report indicated that the recommended tolerances of plus or minus 0.001 in. are too small, but it was the opinion of the Division that these tolerances should be specified, particularly as several large consumers of key-stock specify them.

Passenger-Car Doors

(Proposed S.A.E. Recommended Practice)

The Passenger-Car Body Division recommends that the door-fit clearances given in Table 14 be adopted as S.A.E. Recommended Practice. The nominal door-fit clearances recommended were submitted to passenger-car engineers for comment and met with general approval. It was suggested by several, however, that tolerances should be specified and the recommendation of the Division as submitted has therefore been extended to cover tolerances which are in accord with good body practice.

The Division also recommends that door-flange widths shall be 5/16 in. on the hinge-pillar side and ½ in. minimum on the lock-pillar side and on the bottom. The door-fit tolerances specified do not apply to flush-type doors.

TABLE 14—PROPOSED DOOR-FIT CLEARANCES

Location	Clearance, in.
Hinge Side	1/8, ± 1/32
Lock Side	3/16, + 1/16, — 0
Bottom	1/4, + 1/16, — 0
Top	1/8, ± 1/32
Jamb	3/16, + 1/16, — 0
Bead	3/32, + 1/32, — 0

These clearances are for all types of body, and are measured from wood-to-wood or metal-to-metal before painting.

Door-flange widths shall be 5/16 in. on the hinge-pillar side and ½ in. minimum on the lock-pillar side and on the bottom.

Rubber Bushings

(Proposed S.A.E. Recommended Practice)

The Passenger-Car Body Division recommends the adoption of the following proposal as S.A.E. Recommended Practice because grommets or bushings for electric wiring or conduit when inserted in plain holes punched in sheet metal are quickly cut by the sharp edges and it is a relatively simple and effective process to form a neck to the hole when punching.

Where holes are punched in sheet metal for carrying grommets or bushings, particularly when these are made of rubber, it is recommended that the holes be necked.

Wiring for Beads

(Proposed S.A.E. Recommended Practice)

The Passenger-Car Body Division recommends the adoption of the following proposal for S.A.E. Recommended Practice to simplify the manufacture of parts in which a beaded construction is used such as fenders and splash guards, and to economize in the number of sizes of wire used. The proposal was prepared by a Subdivision and is founded on data indicating the current general practice.

For engine hoods up to and including 36 in. long, top hinge-rods shall be 5/16-in. diameter, and side hinge-rods shall be ¼-in. diameter

For fenders, aprons and splash-guards the wire used for beading shall be No. 11 B.w.g. bright basic steel wire.

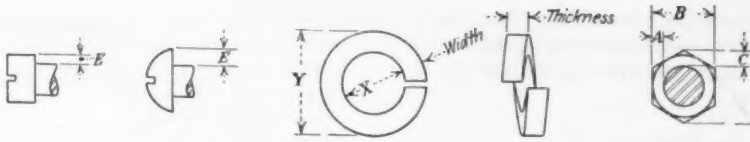


TABLE 15—PROPOSED DIMENSIONS OF LOCK WASHERS.

Fillister Head Machine Screws

Screw Number	Diameter		Clearance[15]	E	X	Standard		Special Light		Special Heavy	
	Screw	Head				Section[16]	Y	Section[16]	Y	Section[16]	Y
2	0.086	0.132	0.003	0.023	0.089	1/32×0.022	0.1515	0.022×0.022	0.1330	1/32×1/32	0.1515
4	0.112	0.175	0.003	0.031	0.115	1/32×1/32	0.1775	1/32×0.022	0.1775	3/64×1/32	0.2087
6	0.138	0.217	0.005	0.040	0.143	3/64×1/32	0.2367	1/32×1/32	0.2055	3/64×3/64	0.2367
8	0.164	0.260	0.005	0.048	0.169	3/64×3/64	0.2627	3/64×1/32	0.2627	1/16×3/64	0.2940
10	0.190	0.303	0.010	0.056	0.200	1/16×3/64	0.3250	3/64×3/64	0.2937	1/16×1/16	0.3250
12	0.216	0.345	0.010	0.065	0.226	1/16×1/16	0.3510	1/16×3/64	0.3510	5/64×1/16	0.3822

Round Head Machine Screws

Screw Number	Screw	Head	Clearance[15]	E	X	Standard Section[16]	Standard Y	Special Light Section[16]	Special Light Y	Special Heavy Section[16]	Special Heavy Y
2	0.086	0.154	0.003	0.034	0.089	1/32×1/32	0.1515	1/32×0.022	0.1515	3/64×1/32	0.1827
4	0.112	0.202	0.003	0.045	0.115	1/16×1/32	0.2400	3/64×1/32	0.2087	5/64×1/32	0.2712
6	0.138	0.250	0.005	0.056	0.143	5/64×1/32	0.2992	1/16×1/32	0.2680	5/64×3/64	0.2992
8	0.164	0.298	0.005	0.067	0.169	5/64×3/64	0.3252	5/64×1/32	0.3252	3/32×3/64	0.3565
10	0.190	0.346	0.010	0.078	0.200	3/32×3/64	0.3875	5/64×3/64	0.3562	3/32×1/16	0.3875
12	0.216	0.394	0.010	0.089	0.226	3/32×1/16	0.4135	3/32×3/64	0.4135	⅛×3/64	0.4760

S. A. E. Standard Bolts

Bolt Diameter	Clearance[15]	A	B	C	D	X	Standard		Special Light		Special Heavy	
							Section[16]	Y	Section[16]	Y	Section[16]	Y
¼	1/32	3/32	⅜	0.128	0.505	9/32	3/32×1/16	15/32	3/32×3/64	15/32	3/32×5/64	15/32
5/16	1/32	3/32	½	0.133	0.578	11/32	⅛×1/16	19/32	⅛×3/64	19/32	⅛×3/32	19/32
⅜	1/32	3/32	9/16	0.137	0.650	13/32	⅛×3/32	21/32	⅛×1/16	21/32	⅛×⅛	21/32
7/16	1/32	3/32	⅝	0.173	0.722	15/32	5/32×⅛	25/32	5/32×1/16	25/32	5/32×5/32	25/32
½	1/32	⅛	¾	0.183	0.866	17/32	11/64×⅛	⅞	11/64×1/16	⅞	11/64×11/64	⅞
9/16	1/32	5/32	⅞	0.224	1.011	19/32	3/16×⅛	31/32	3/16×3/32	31/32	3/16×3/16	31/32
⅝	1/32	5/32	15/16	0.229	1.083	21/32	13/64×5/32	1 1/16	13/64×3/32	1 1/16	13/64×13/64	1 1/16
11/16	1/32	5/32.	1	0.234	1.156	23/32	7/32×3/16	1 5/32	7/32×⅛	1 5/32	7/32×7/32	1 5/32
¾	1/16	5/32	1 1/16	0.239	1.228	13/16	¼×3/16	1 5/16	¼×⅛	1 5/16	¼×¼	1 5/16
⅞	1/16	3/16	1¼	0.284	1.444	15/16	17/64×3/16	1 15/32	17/64×5/32	1 15/32	17/64×17/64	1 15/32
1	1/16	7/32	1 7/16	0.330	1.660	1 1/16	5/16×¼	1 11/16	5/16×3/16	1 11/16	5/16×5/16	1 11/16
1⅛	1/16	¼	1⅝	0.376	1.877	1 3/16	⅜×¼	1 15/16	⅜×3/16	1 15/16	⅜×⅜	1 15/16
1¼	1/16	9/32	1 13/16	0.422	2.093	1 5/16	7/16×¼	2 3/16	7/16×5/16	2 3/16	7/16×5/16	2 3/16
1⅜	1/16	5/16	2	0.468	2.310	1 7/16	7/16×5/16	2 5/16	7/16×¼	2 5/16	7/16×⅜	2 5/16
1½	1/16	11/32	2 3/16	0.513	2.527	1 9/16	½×5/16	2 9/16	½×¼	2 9/16	½×⅜	2 9/16

All dimensions in inches.

[15] Inside diameter of washer less diameter of bolt or screw.

[16] Lock-washer sizes should be designated by giving the bolt diameter, the lock-washer width and the thickness in the order given; as ½ × 11/64 × ⅛.

Investigation of this whole subject indicated that there is a tendency to make fenders without beads, but the Division does not consider such practice desirable as it leaves the fender edges sharp.

Body Nomenclature

(Proposed Revision of S.A.E. Standard)

One of the important subjects considered by the Passenger-Car Body Division is the selection of appropriate names for the several types of passenger-car bodies. The present variety of names applied to given types of body tends toward confusion in the minds of passenger-car purchasers and creates difficulties for the sales and service departments of the automobile manufacturers. A Subdivision drafted a series of suggested names for bodies which was circularized to secure suggestions. The comments submitted formed the basis for further consideration of the subject and indicated to the Division the necessity for standardization of body nomenclature, although, no matter what nomenclature is eventually adopted, various terms will probably continue to be used. The members of the Division, in reaching their conclusions, have borne in mind the derivations of the several terms, their application to their now more or less obsolete horse-drawn prototypes and the accepted European or international usage.

The use of the illustrations with the descriptions of the various types of body is recommended as the best method of indicating clearly what each type represents. The Division also recommends that other national organizations such as the National Automobile Chamber of Commerce, the American Automobile Association, the Automobile Body Builders Association, the Carriage Builders National Association, and the Vehicle Manufacturers Association, as well as the automotive press, give the recommendation their support by urging upon all manufacturers and distributors of automobiles the desirability of adhering to the standard nomenclature. This report is intended to supersede the present standard body-nomenclature printed on pages K20 and K21 of the S.A.E. Handbook.

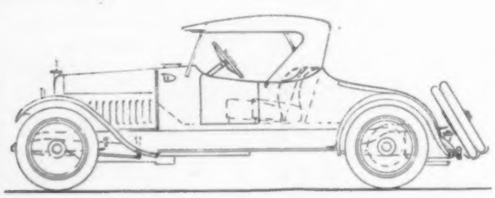


Fig. 44—Roadster

Roadster (Fig. 44)—A small open-type body, having one fixed cross-seat for two passengers and a space or compartment at the rear for carrying luggage. Folding seats fitting into the luggage compartment are sometimes used. The conventional type has two doors and a folding roadster top with emergency side-curtains that are removable.

Coupe (Fig. 45) — An enclosed single-compartment body, with one fixed cross-seat. This seat may be straight and accommodate two persons or be staggered and accommodate three persons. With the latter arrangement, a folding seat may be placed beside the driver's seat, thus making it a four-passenger body. The conventional body has two doors and two movable

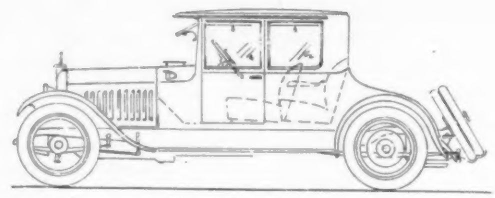


Fig. 45—Coupe

glass windows on each side, the roof is permanent, and there is a luggage compartment at the rear.

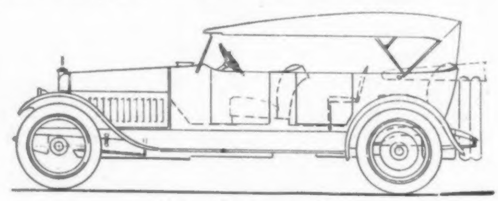


Fig. 46—Phaeton

Phaeton[17] (Fig. 46) — An open-type body, with two fixed cross-seats for four or five passengers. Folding seats in the tonneau for two additional passengers are sometimes used. The conventional body has four doors and a folding phaeton-top with emergency side-curtains that are removable.

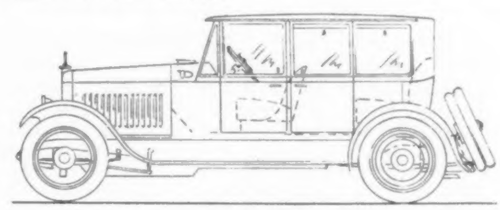


Fig. 47—Sedan

Sedan (Fig. 47) — An enclosed single-compartment body, with two fixed cross-seats for four or five passengers. Sometimes the front seat is divided by an aisle. Folding seats in the tonneau for two additional passengers are sometimes used. The conventional body has four doors, but some models have only two. There are three movable glass windows on each side and the roof is non-collapsible.

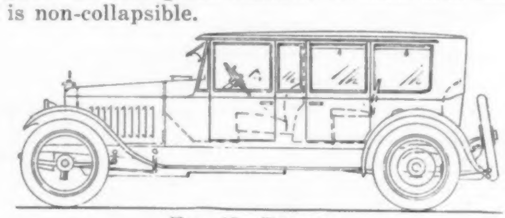


Fig. 48—Berline

Berline (Fig. 48) — A body of the same general description as the sedan, except that there is a partition at the rear of the driver's seat that makes it an enclosed two-compartment body. Generally one glass window in the partition is made so that it can be moved horizontally or vertically.

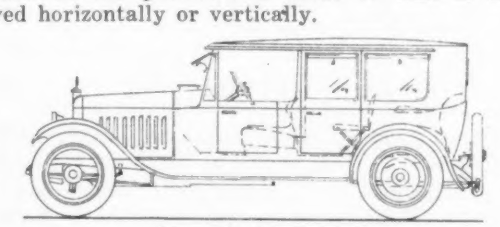


Fig. 49—Limousine

Limousine (Fig. 49)—A partially enclosed body, with a non-collapsible roof that extends the full length of the body and is attached at the front to the windshield standards. Only the rear portion of the body up to the partition at the rear of the driving seat is fully enclosed. Forward of this partition, the sides are en-

[17] The principal reason for recommending the use of the term "phaeton" instead of the term "touring" is that the latter has lost its significance as applying to any particular type of body, as all types are used for touring. The term "phaeton" is used extensively in Europe and to a considerable extent in America in connection with passenger-cars; it is the name of a horse-drawn prototype; it is inelegant and in a technical sense is not distinctive of any particular type of motor vehicle body.

closed only from approximately the belt downward. There are two low doors and one fixed cross-seat for two in the forward section. In the rear section there is one fixed cross seat for two or three. Folding seats for two additional passengers are sometimes used. There are two doors in this section and two movable glass windows on each side.

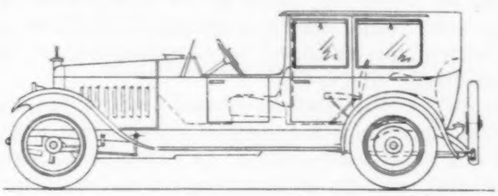


FIG. 50—BROUGHAM

Brougham (Fig. 50)—A body of the same general description as the limousine, except that the non-collapsible roof extends only over that portion of the body that is entirely enclosed.

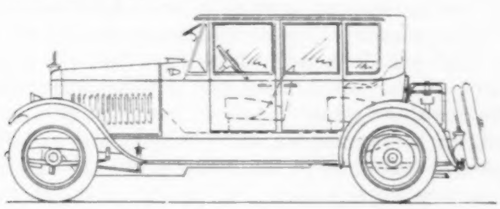


FIG. 51———————

———[18] (Fig. 51)—An enclosed single-compartment body with two fixed cross-seats, close-coupled and allowing the minimum fore-and-aft seating space for four passengers. The conventional body has four doors and there may be movable glass side-windows in the doors only, with solid rear quarters or the quarters may have small movable or fixed windows. There is a luggage compartment at the rear.

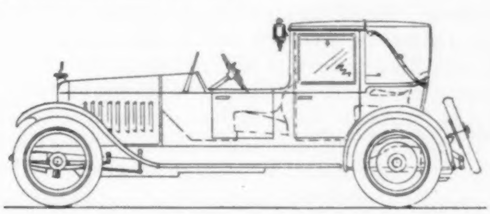


FIG. 52—LANDAULET

Landaulet (Fig. 52)—A body similar in appearance to the brougham, except that the enclosed section is shorter from back to front and the roof is fully collapsible up to the partition at the back of the driver's seat. The body has one fixed cross-seat in the rear section for two or three passengers, two doors made with either flappers or hinged upper parts, and glass windows in the doors only. The rear quarters, back and top are covered with leather or fabric. There are outside joints to support the top.

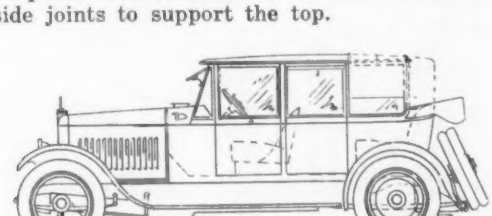


FIG. 53—SEDAN-LANDAULET

Sedan-Landaulet (Fig. 53)—A body of the same general description as the sedan, except that the top back of the rear doors is collapsible. Forward of this point the roof is non-collapsible and the windows are the same in number as in the sedan. The rear quarters, the back above the belt and the roof are covered with leather or fabric.

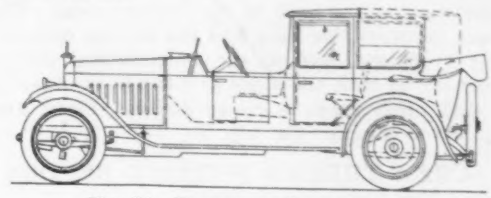


FIG. 54—BROUGHAM-LANDAULET

Brougham-Landaulet (Fig. 54) — A body that bears the same relation to the brougham as the sedan bears to the sedan-landaulet.

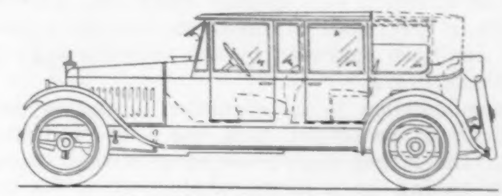


FIG. 55—BERLINE-LANDAULET

Berline-Landaulet (Fig. 55)—A body that bears the same relation to the berline as the sedan-landaulet bears to the sedan.

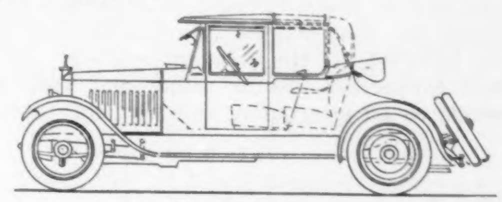


FIG. 56—COUPE LANDAULET

Coupe-Landaulet (Fig. 56) — A body that bears the same relation to the coupe as the sedan-landaulet bears to the sedan.

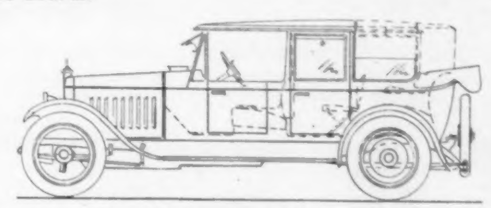


FIG. 57—LIMOUSINE-LANDAULET

Limousine-Landaulet (Fig. 57)—A body that bears the same relation to the limousine as the sedan-landaulet bears to the sedan.

——————— *Landaulet*[18]—A body that bears the same relation to the ——————— as the sedan-landaulet does to the sedan.

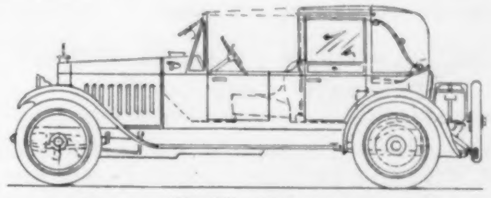


FIG. 58—CABRIOLET

Cabriolet (Fig. 58)—A body similar in appearance to the brougham and having the general characteristics of the landaulet, except that the falling pillar-hinge is set back from the pillar line and shows the curved parting line through the leather. The rear section is therefore longer than that of the landaulet. The body has one fixed cross-seat for two or three and folding seats on the partition for two additional passengers. The

[18] The name for this type of body has not been determined.

doors in the rear section are made with either flappers or hinged upper parts, and there are glass windows in the doors only. The top is fully collapsible, including the partition at the back of the driver's seat. The upper rear quarters, the back and the top are covered with leather or fabric, and in the conventional design the top corners on both the sides and the back, have larger radii than other types of closed bodies. There are outside joints to support the top.

SCREW-THREAD DIVISION REPORT

Pressure-Gage Connections

(Proposed S.A.E. Recommended Practice)

The Screw-Thread Division recommends the adoption as S.A.E. Recommended Practice of the pressure-gage connections given in Fig. 59 and Table 16. The recommendation is the result of investigations by a Subdivision and has been approved by the pressure-gage manufacturers and users.

The recommended 1/4-in. diameter tubing is used on the majority of passenger cars, the 5/16-in. tubing on several of the larger high-powered passenger cars, and the 3/8-in. tubing on a large number of motor trucks. The size of aperture recommended is the same for all three sizes of connection as the area of this opening need not vary for different tubing sizes. As the aperture is frequently drilled in a plug that is screwed into the connection, and as plugs fitting a hole tapped with No. 10-32 thread are usually used, the specification of this thread is included in the recommendation. A 1/8-in. pipe-thread connection also is sometimes used, and is recommended as an alternative construction.

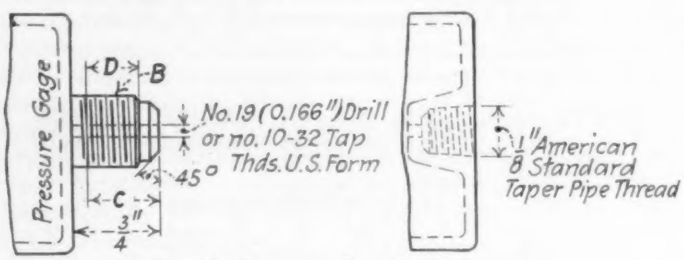


Fig. 59—Pressure-Gage Connections

TABLE 16—PROPOSED PRESSURE-GAGE CONNECTIONS

Tubing Diameter, in.	B[19]	C Minimum Usable Thread	D Minimum Usable Thread
1/4	7/16 — 20	1/2	11/32
5/16	1/2 — 20	9/16	3/8
3/8	5/8 — 18	5/8	13/32

The construction shown at the right should be used when the construction shown at the left is not provided.

[19] S.A.E. thread. All dimensions in inches.

TIRE AND RIM DIVISION REPORT

Pneumatic Tires and Rims

(Proposed Revision of S.A.E. Standard)

The Tire and Rim Division recommends that the present S.A.E. Standard for Pneumatic Tires and Rims, page G1, S.A.E. Handbook, be revised by eliminating the 32 x 3½, 33 x 4 and 33 x 4½-in. rim sizes and the corresponding regular and oversize tire sizes, and by adding the 30 x 3½-in. straight-side rim and the 31 x 4-in. oversize straight-side tire. The adoption of this proposal will reduce the present standard to five rim sizes and nine tire sizes for passenger cars and an equal number for motor trucks. As it is recognized, however, that the standardization of tires and rims is influenced by other than purely technical considerations, the Division recommends the proposal for adoption as S.A.E. Recommended Practice.

Particular emphasis is laid on the fact that this recommendation is not intended to call for immediate discontinuation of all other tire or rim sizes. Non-standard sizes will of necessity continue in production on a decreasing scale until those automotive vehicles now in service which are equipped with non-standard rims and tires are finally discarded.

A review of the standardization of pneumatic tires shows that the original list of sizes which was first adopted by the Association of Licensed Automobile Manufacturers nearly 15 years ago has been changed at very frequent intervals, additions generally being made until during the latter part of the recent war a definite schedule for eliminating certain sizes by groups at stated intervals of time was approved. The standard, however, instead of becoming more effective, was more or less disregarded by many car and tire manufacturers for use on new equipment. This condition was one of the influences that led to a lack of cooperative effort and the differences of opinion among the groups interested.

As the result of this situation, a conference was held in Cleveland in November 1920 which was attended by tire, rim and automobile manufacturers and at which a resolution was passed that the Society should appoint a special committee representing the National Automobile Chamber of Commerce, the Rubber Association of America and the Society of Automotive Engineers for the purpose of carefully studying the existing conditions and preparing a recommendation which would meet with the approval of the industry and the National organizations representing its various branches.

The Committee thus appointed conferred with the automobile and tire manufacturers and carefully analyzed the situation. Much thought was devoted to coordinating the many interests involved and the proposal now recommended was finally agreed upon, submitted to the Standardization Committee of the Tire Manufacturers' Division of the Rubber Association of America, which approved it, and to the National Automobile Chamber of Commerce. The report is now submitted to the Standards Committee and the Society for approval and adoption in compliance with the regular procedure of the Society.

TABLE 17—PROPOSED S. A. E. TIRE AND RIM RECOMMENDED PRACTICE

Type	Rim		Tire Size		Tire-Seat Diameter
	Size	Type	Regular	Oversize	
Passenger Car	30x3½	C	30x3½	31x4	23
	30x3½	SS	......	31x4	23
	32x4	SS	32x4	33x4½	24
	32x4½	SS	32x4½	33x5	23
	34x4½	SS	34x4½	35x5	25
Motor Truck	34x5	SS	34x5	36x6	24
	36x6	SS	36x6	38x7	24
	38x7	SS	38x7	40x8	24
	40x8	SS	40x8	42x9	24
	44x10	SS	44x10	......	24

All dimensions in inches.

The list of tire and rim sizes revised in accord with the proposal of the Division is given in Table 17. The Division recommends that the proposed list be used by passenger-car and motor-truck designers to select tire sizes for apparatus not yet in production, or at such a

time as a change to a recommended size can be logically made.

It is also recommended that for figuring speedometer gear-ratios and fender and wheel housing clearances, the actual tire widths and outside diameters be measured on the tires to be used.

TRACTOR DIVISION REPORT

Tractor Drawbar Height

(Proposed Revision of S.A.E. Standard)

The Tractor Division recommends that the present S.A.E. Standard for Tractor Drawbar Height, page K40, S.A.E. Handbook, be extended to include the additional dimensions specified in Table 18, as recommended practice for hitching farm-implements to tractors. The present S.A.E. Standard does not differentiate between 12 and 14-in. plows or the number of plows in a gang, nor does it indicate a recommended practice for the location of the tractor hitch with regard to the furrow.

The proposed extension has been submitted to the American Society of Agricultural Engineers and the National Implement & Vehicle Association so that it may be generally adopted as an Agricultural Equipment Standard in pursuance of the arrangement made between the Society of Automotive Engineers and those organizations whereby standards approved by any two of them are known as American Agricultural Equipment Standards.

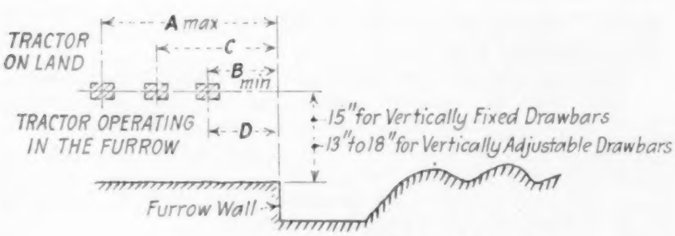


Fig. 60—Tractor Drawbar Height

TABLE 18—PROPOSED TRACTOR DRAWBAR HEIGHTS

Plow	Two-Bottom		Three-Bottom		Four-Bottom	
	12-in.	14-in.	12-in.	14-in.	12-in.	14-in.
A	30	30	32	32	40	40
B	15	15	20	20	24	24
C	17	20	23	26	28	32
D	15	15	20	20	24	24

A—Maximum position for good operation, ordinarily the best possible position.
B—Minimum position for good operation with the tractor operating on the land.
C—Proper or best average position when the tractor operates on the land.
D—Minimum hitch position when the tractor operates in the furrow.

TRANSMISSION DIVISION REPORT

Transmission Tire-Pump Mountings

(Proposed Revision of S.A.E. Standard)

The Transmission Division was requested to revise the present S.A.E. Standard for tire-pump mountings of the transmission type, page E1, S.A.E. Handbook, by cutting back the inside edges of the large-type mounting pad, so as to allow more clearance for the idler-pinion carrier.

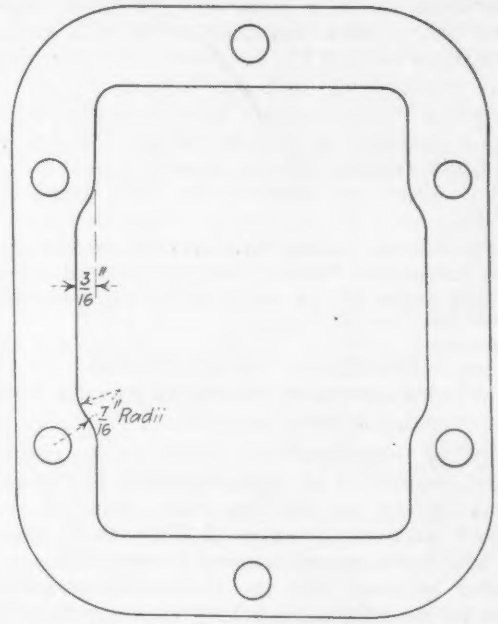


Fig. 61—Tire-Pump Mounting

It was stated that this change had already been put into practice and, as no changes in the dimensions of the present standard are involved, the Transmission recommends that the revision be made as shown in Fig. 61.

Clutch Facings

(Proposed S.A.E. Recommended Practice)

Standardization of clutch facings was proposed to and has been carefully considered by the Transmission Division to reduce the number of sizes to a practical minimum and to secure the resulting economies in the manufacturing and, to a large extent, the service branches of the automotive industry.

TABLE 19—PROPOSED MULTIPLE-DISC CLUTCH-FACING SIZES

Outside Diameter, in.	Inside Diameter, in.	Thickness, in.	Tolerances, in.	
			Outside Diameter	Inside Diameter
8½	6, 6¼, 6½	5/32 ±0.005 for all sizes	Woven +0.000 −1/16	Woven +1/16 −0.000
8¼	6, 6¼, 6½		Molded +0.000 −1/32	Molded +1/32 −0.000
8	5¾, 6, 6¼			

A careful study was made of existing practice by a Subdivision and a tentative report submitted for the consideration of the Division and the clutch manufacturers. This report was published on page 285 of the

TABLE 20—PROPOSED SINGLE-PLATE CLUTCH-FACING SIZES

Size	Type	Outside Diameter, in.	Inside Diameter, in.	Thickness in.	Tolerances, in.	
					Outside Diameter	Inside Diameter
8	Woven	7⅞	5⅝	⅛ or 5/32 ±0.005 for all sizes	Woven +0.000 −1/16	Woven +1/16 −0.000
	Molded	8				
10	Woven	9⅞	6¾		Molded +0.000 −1/32	Molded +1/32 −0.000
	Molded	10				
12	Woven	11⅞	8¼			
	Molded	12				

October issue of THE JOURNAL. It is, of course, not expected that clutch manufacturers will revise their clutch designs to take the proposed clutch-facings before they can economically and conveniently do so.

The facing manufacturers have indicated their desire for such a standard as is proposed and the Transmission Division now recommends for adoption as S.A.E. Recommended Practice the clutch-facing sizes listed in Tables 19 and 20.

The Division is giving consideration to clutch facings with the intention of standardizing rivets and their location. This phase of the work will require much further study.

TRUCK DIVISION REPORT

THREE-JOINT PROPELLER-SHAFTS

(Proposed S.A.E. Recommended Practice)

The use of long-wheelbase motor trucks requiring an additional support at or near the center of the propeller-shaft has, during the last few years, resulted in a great number of different designs of front-shaft rear shaft-end on which the center bearing is mounted.

It being believed that the three-joint propeller-shaft has been in use long enough to permit standardizing the front-shaft rear shaft-ends, the Society was requested to undertake the work. The subject was assigned to the Truck Division and a Subdivision consisting of J. R. Coleman, chairman, H. B. Knap and J. W. B. Pearce was appointed to obtain information on present practice and to prepare a tentative report.

A progress report was submitted by the Subdivision at the April 1921 meeting of the Truck Division which indicated that the adoption of a standard for the front-shaft rear shaft-ends was desirable and would result in considerable economy in manufacturing, assembling and servicing.

After holding several meetings the Subdivision submitted a final report on Oct. 13 which was favorably acted upon by the Truck Division by letter ballot. The report follows and is submitted for adoption as S.A.E. Recommended Practice.

Self-aligning bearings provided for taking radial loads only shall be used for supporting the rear shaft-end of the front shaft of motor-truck, three-joint propeller-shafts. All thrust loads shall be carried by the transmission and the rear axle.

The bearing shall be clamped to the shaft in accord with good bearing-mounting practice.

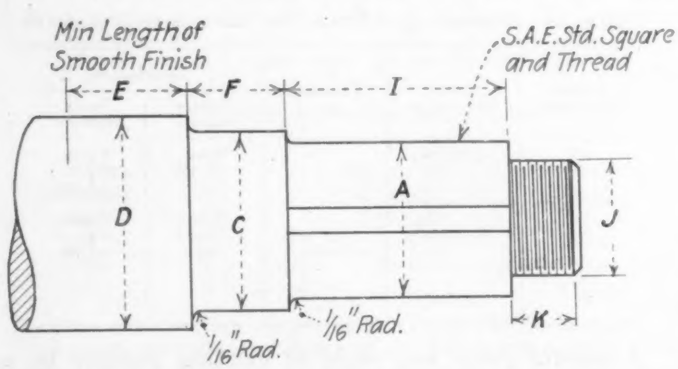


FIG. 62—PROPELLER SHAFT FOR USE WHERE THE REAR END OF THE FRONT SHAFT IS SQUARE

Nominal Diameter[20]	A	C	D	E	F	I	J[21]	K[21]
1¼	1.250 1.245	1.378 1.377	1 11/16	1	43/64	1 7/16	1-20	11/16
1⅜	1.375 1.370	1.575 1.574	1⅞	1 1/16	21/32	1 11/16	1-20	11/16
1½	1.500 1.495	1.772 1.771	2 1/16	1⅛	43/64	1 11/16	1-20	11/16
1¾	1.750 1.745	1.968 1.967	2¼	1 3/16	1	2 3/16	1¼-18	13/16
2	2.000 1.995	2.166 2.165	2 7/16	1¼	1 5/64	2 11/16	1¼-18	13/16

[20] All dimensions in inches.
[21] As specified in the S.A.E. Standard for Square Fittings, page C12, S.A.E. HANDBOOK.

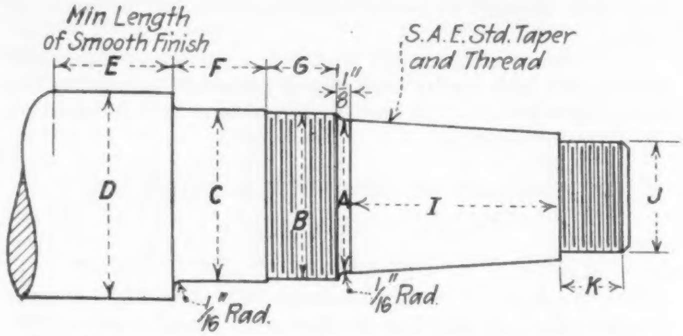


FIG. 63—PROPELLER SHAFT WHERE THE REAR END OF THE FRONT SHAFT IS TAPERED

TAPER PER FOOT = 1.500 ± 0.005 IN.

Nominal Diameter[22]	A	B-Diameter and Thread	C	D	E	F	G	I[23]	J[23]	K[23]
1¼	1.251 1.249	1⅜-18	1.378 1.377	1 11/16	1	43/64	⅝	1⅜	1-20	11/16
1⅜	1.376 1.374	1½-18	1.575 1.574	1⅞	1 1/16	21/32	⅝	1⅞	1-20	11/16
1½	1.501 1.499	1⅝-16	1.772 1.771	2 1/16	1⅛	43/64	¾	1⅞	1-20	11/16
1¾	1.751 1.749	1⅞-16	1.968 1.967	2¼	1 3/16	1	¾	2⅛	1¼-18	13/16
2	2.001 1.999	2⅛-16	2.166 2.165	2 7/16	1¼	1 5/64	¾	2⅞	1¼-18	13/16

[22] All dimensions in inches.
[23] As specified in the S.A.E. Standard for Taper Fittings, page C14, S.A.E. HANDBOOK.

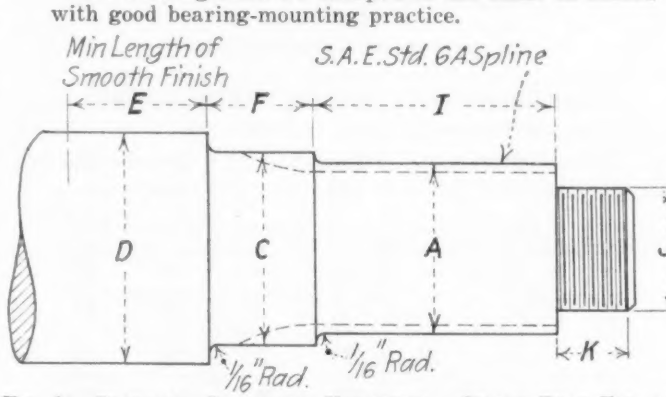


FIG. 64—PROPELLER SHAFT FOR USE WITH A SPLINE REAR END OF FRONT SHAFT

Nominal Diameter[24]	A	C	D	E	F	I[25]	J[25]	K[25]
1¼	1.250 1.245	1.378 1.377	1 11/16	1	43/64	1 7/16	1-20	11/16
1⅜	1.375 1.370	1.575 1.574	1⅞	1 1/16	21/32	1 11/16	1-20	11/16
1½	1.500 1.495	1.772 1.771	2 1/16	1⅛	43/64	1 11/16	1-20	11/16
1¾	1.750 1.749	1.968 1.967	2¼	1 3/16	1	2 3/16	1¼-18	13/16
2	2.000 1.995	2.166 2.165	2 7/16	1¼	1 5/64	2 11/16	1¼-18	13/16

Spline fitting dimensions shall be as specified in the S.A.E. Standard for 6A spline fittings, page C18, S.A.E. HANDBOOK.

[24] All dimensions in inches.
[25] As specified in the S.A.E. Standard for Taper Fittings, page C14, S.A.E. HANDBOOK.

Shaft-ends shall be in accord with the S.A.E. Standards for square, taper or spline fittings, pages C12, C14 and C18, S.A.E. HANDBOOK.

The following S.A.E. Standard annular ball bearings of the medium series, page C28, S.A.E. HANDBOOK, shall be used on the shaft-ends recommended:

Shaft-End, In.	Bearing, No.
1¼	307
1⅜	308
1½	309
1¾	310
2	311

The shaft-end dimensions given in Figs. 62, 63 and 64 shall be used.

STILL MARINE ENGINE

THE Still engine built by Scotts' Shipbuilding & Engineering Co., Ltd., Greenlock, is, we understand, the largest of the type so far constructed. It is of the slow running marine type suitable for the merchant service.

As is generally known, the Still oil engine is a combination of an oil and a steam engine. The main source of power is oil consumed within a cylinder for the down-stroke, operating in this particular machine on the two-cycle principle, while steam forms a supplementary source of power, being used for the up-stroke. The primary aim of the design is to reduce heat losses to a practical minimum. This is accomplished by raising steam by (*a*) heat taken up by the water circulating in the cylinder jacket under working steam pressure and (*b*) heat recovered from the exhaust gases by regenerators and feed-water heaters. All of the first heat goes to form steam. In the second scheme water is evaporated in the regenerators and the feed water is raised to boiler temperature in the heaters.

To carry this out in practice, it is necessary to provide certain steam plant, and steam inlet and exhaust-valves for the cylinders. There are, however, certain compensating advantages, and the most marked of these is that no compressed air is required for starting and maneuvering, because under these conditions, the engine is really a steam engine with the flexibility always associated with that class of machine. This makes the engine very easy to handle and, of course, allows it to run at very low speeds. Another direct result of this combination is that a low compression-pressure can be used with absolute certainty of "firing," the reason being that the cylinder walls are kept at steam temperature by water circulating in the jacket from the regenerator. During compression the air charge picks up heat from the walls instead of being cooled by them for the greater portion of the stroke, as occurs in the Diesel engine. The relatively low compression-pressure enables lighter scantlings to be used, or alternatively provides a larger margin of safety, as the maximum pressure possible in the cylinder is a function of the compression-pressure. It further provides a useful margin for any loss of pressure in service, as the pressure used in practice in this engine, although considerably below that of the Diesel engine practice, is well above the minimum pressure that will produce the temperature required to insure combustion. In the Scotts engine, we understand the normal compression-pressure used is about 300 lb. per sq. in. The engine is a single-cylinder unit of 22-in. diameter and 36-in. stroke. Scavenging air is supplied by a motor-driven Reavell turbo blower. This discharges into a large tank to minimize the fluctuations of pressure, whence it passes to the cylinder by way of the bedplate and columns.

The exhaust gases pass from the engine to a regenerator, in this case a small Cochran boiler, set above the level of the combustion cylinder jackets. The gases finally pass through a feed-water heater on their way to the atmosphere. Steam is taken from the regenerator to the engine and expanded in two stages to the condenser. To effect this, owing to the experimental engine having only a single cylinder, it has been necessary to provide a small auxiliary steam cylinder. This forms the high-pressure cylinder and the lower end of the main cylinder serves as the low-pressure cylinder, whence the steam passes to the condenser. Compounding in, say, a six-cylinder engine would be secured by using the lower ends of two combustion cylinders as high-pressure steam cylinders and those of the other four similar cylinders as low-pressure steam cylinders.

The combustion cylinder jacket, as has been stated, is kept under steam pressure and temperature by a circulation of water from the regenerator through the jacket and back again; no pump is necessary, as the circulation is a natural thermal one. Thus, when the engine is cold and the burner under the regenerator is lighted, the water begins to circulate from the regenerator to the cylinder jacket, heating the latter gradually until the desired steam temperature and pressure are reached. When the engine is running and the regenerator burner has been shut off, the circulation reverses and takes place from the cylinder jacket to the regenerator because of the heat added to the jacket water through the cylinder liner, and the steam produced finds its way by the pipes provided to the regenerator. The steam and exhaust-valves are of the piston type, and are operated by oil under pressure.

All the pumps necessary for the engine, except the scavenging blower, the forced-lubrication pump, valve-gear oil-pump, circulating pump, air-pump and feed-pump are driven from the main engine-shaft. A complete system of oil-measuring and water-measuring tanks is provided. The latter are placed in the space beneath the regenerator.

Special provision is made in the design of the engine for expansion and contraction due to heat, the combustion cylinder being held by a joint at its lower end only, thus being free to expand upward as the temperature rises. The steam end of the cylinder is also free to expand. The cylinder has no cover in the ordinary sense of the word, and there is an entire absence of cams and rods about the cylinder, even the fuel-valve operating automatically by the action of the fuel-pump. The engine works on the solid-injection principle, that is to say, no air is used to atomize the oil during injection into the cylinder.

The following are the extracts from reports on the engine made by some French engineers representing commercial interests:

> The fuel-consumption figures . . . are extremely low. One can estimate that with a good four-cycle Diesel engine, the quantity of oil consumed would have been at least 10 per cent and with a two-stroke engine 20 per cent higher. It is further necessary to take into account the point that a provisional single-cylinder installation causes losses in efficiency that would not be found in a complete installation intended for normal service. In particular the high-pressure steam cylinder was isolated from the group and did not completely benefit by the favorable conditions in which the steam expands in a Still cylinder. The pressure pump for the oil required to operate the steam valve-gear was driven by a small auxiliary engine with a high steam consumption, due to the engine-driven pump being temporarily out of action. It is justifiable therefore to estimate that in a normal installation the fuel consumption at equal power would be still further reduced.
>
> . . . . The Still engine is a machine of the greatest interest which seems able to render great service in all cases where it is necessary to obtain great facility of maneuver, powerful starting torque and large variation of load.
>
> During the full-load trial the power was 343 b. hp., from which has to be deducted 14.1 b. hp. absorbed by the scavenging pump, leaving 329 b. hp. available at the engine-shaft. The fuel consumption was 123.4 lb. per hr., that is to say, a consumption of 0.360 lb. per b. hp-hr.—*Engineering* (London).

DOMESTIC PURCHASING-POWER

EXPORTS of wheat, cotton, copper and other raw materials have placed the United States in a dominant position in the world commodity markets. Natural resources and modern methods of production have enabled the United States to produce more commodities of those classes than the domestic market could consume at prices enabling the American producer to meet competitors in the international markets.

Through the century preceding 1914, the countries of northwestern Europe had gradually attained a similar dominance in the international market for manufactured goods. In the beginning this was the result of an historic superiority in skill of production and distribution, together with the early development of the use of steam power. Countries less advanced industrially were anxious to exchange food and other raw materials for the manufactures of Europe.

This specialization has resulted in the development of a population in the leading countries of northwestern Europe far in excess of the ability of their soils to feed according to the European standard of life, and capable of producing manufactured goods beyond the power of their home markets to consume. Japan likewise has an excess population that is rapidly gaining industrial skill. If these countries cannot market their excess manufactures, the population must reduce its standard of life or millions must emigrate. Sheer necessity has forced manufacturers in these countries into the struggle for remote markets, and the pressure of a skilled population enables them to sell at prices that determine the world markets for many classes of manufactured products. This sharp competition does not preclude competition by the United States in manufactures, but it does determine the directions in which American selling efforts can be most favorably expended.

The population of the United States is now about equal to that of the United Kingdom and Germany combined. It exceeds by probably 40,000,000 the population of all of South America. The standard of life of the American people is equalled only by that of the people of Canada and Australia, the combined population of which is only 15,000,000 or 14 per cent of that of the United States.

The United States is not sufficiently dependent on foreign markets to justify the belief that business recovery in this country must await recovery abroad. At prices determined in the international markets American raw materials for export will find an outlet. By far the greater part of the entire manufactured product of the country has always been sold at home and as price adjustments are completed the domestic market will again absorb the major portion of our production.

It is true that the buying power of the domestic consumer has been much curtailed. High taxes have cut heavily into the sums that might have been spent for clothing, furniture and all those articles that have made the life of the average American family so rich in comforts and luxuries. Declines in the prices of agricultural products and widespread unemployment have reduced the buying ability of a large part of the population, and high rents, high fuel costs and high transportation charges have operated in the same direction. Many of these items represent temporary maladjustment, and their effects will lessen gradually and tend to disappear eventually.

Except in a few areas the widespread and severe unemployment has not materially reduced savings bank deposits, while in some localities steady gains in such deposits have been made throughout the period of depression. Sharp curtailment of income has impressed the necessity of saving on many who failed to take advantage of temporarily higher incomes. Economy has become fashionable. The time has passed when any considerable section of the public will buy regardless of cost. Sales policies based on a belief that buying can be stimulated by artificial methods and that another era of extravagant buying can be induced under present conditions will not succeed.

The American consumer, however, has suffered no material permanent curtailment of purchasing power. Goods of all kinds, in large volume, can be sold in every part of the United States today, if they are staple in character, and if prices are such as to represent real values to conservative purchasers. As the volume of goods thus sold expands, employment will automatically increase and in turn, new purchasing power will develop. The domestic market assures the American producer of an outlet.—*Commerce Monthly.*

STANDARDIZATION AS AN AID TO SIMPLIFICATION

SIMPLIFICATION, as defined in the standard dictionaries, is the act or process of rendering simple or more simple, or making less complex or difficult.

Standardization is defined as the act or process of conforming to any measure of extent, quantity, quality, or value established by law or by general usage and consent.

Thus the procedure of a company in limiting its types and sizes of product to the lowest number possible is simplification, not standardization.

Standardized products conform to those standards established by general usage and consent; in the automotive industry, to standards approved by the Society of Automotive Engineers, or the Government; the former because S. A. E. Standards have been based on usage and have met with general consent as evidenced by the letter ballots of the Society members, and the latter because the Government has legalized certain generally used standards such as standards of time, weight and measure.

To obtain the greatest simplification, standardization must be carried to the greatest possible extent. Simplification is a plant problem; standardization a National problem. Simplification can be obtained only by the cooperation of department heads of a company; standardization by the cooperation of executives and engineers in general.

PRODUCTION OF LIQUID AIR

IN the plant for liquefying air by the Hampson process, installed at the Bureau of Standards, a four-stage steam-driven compressor delivers air at room temperature and under a pressure of approximately 3000 lb. per sq. in.; this air then passes through an oil and water trap and a purifying train containing reagents that remove the carbon dioxide and water vapor. The air thus compressed and purified is delivered to the liquefier, in which after passing through a coil of copper tubing, the air is allowed to expand freely to approximately atmospheric pressure. Where this drop in pressure takes place, there is a corresponding drop in the temperature of the air. The expanded air before leaving the liquefier circulates around the copper coil that contains the sompressed air, thus cooling it so that in continuous operation a cycle of progressive cooling is maintained until the temperature ultimately reaches the liquefying point. The liquefier is constructed so that the air that is condensed is delivered into a receiving vessel. The gaseous air exhausted from the liquefier is returned to the intake of the compressor for succeeding cycles because it has been purified and when used repeatedly will be found to be very much less exhausting on the purifying reagents that are employed to remove all traces of carbon dioxide and water vapor.—From Bureau of Standards Technical News Bulletin No. 55.

Automotive-Engineering Research

By H. C. Dickinson[1] Detroit Section Paper

EMPHASIS is placed upon the propriety of applying the term "research" only to such lines of investigation as are capable of yielding general results that can be utilized by other than the original observers. The distinction between research thus defined and much else that can be classed correctly as research according to its ditionary definition is explained.

In stating the purpose and aim of the Research Department of the Society, the divisions of the thought include research personnel requirements, the support of research, the importance of research, problems suitable for research in the industrial, educational and independent laboratories, the general research program and the avoidance of duplication of research work.

The fuel and the highway problems are enlarged upon as insistently demanding immediate research information and a strong recommendation is made that all members interested in research reread and study the papers covering these subjects that have been published in The Journal, reference being made to the accompanying bibliographical list.

RESEARCH is defined in the dictionary as being "a diligent search for information," but this fails to assist us to any great degree in arriving at a definite understanding of exactly what we mean by automotive-engineering research. The term research has been applied correctly, of late, to many fields of endeavor that are not at present within the scope of the engineering research department of the Society of Automotive Engineers. For instance, the modern department of sales research, however important and interesting, must be omitted for the present. One definite limitation that physicists, chemists, research engineers and all dyed-in-the-wool scientists like to stipulate in connection with the term research, whether correctly or not, is that the term shall apply only to such lines of investigation as are capable of yielding general results, that is results that can be put into the form of general laws, equations, charts, tables or curves, and utilized by other than the original observers.

The distinction between research thus defined and much else that can be classed correctly as research according to the dictionary can be illustrated. For instance, the trial of an individual design of manifold, the testing of a single newly designed engine, road trials for the development of a new chassis model, ordinarily would not constitute research in this sense. If, however, the device under test were one of a series differing only in some definite particular, the series of tests, together with the comparison of their results, might constitute such research. Thus, tests of a series of manifolds differing by definite amounts in diameter, heated area or temperature, or tests of a series of engines differing in a single particular, such as the valve area or the shape of the combustion-chamber, might lead to general conclusions regarding the effect of these particular changes in design. This series of tests would be classed properly as research, according to this definition, when the results were put in such form that they could be applied to future design. In using the term "research" in this paper, its meaning is limited to the foregoing conception of the term, since this will assist in drawing a line of distinction which is essential to a correct understanding of the aims of the Research Department.

Research as here defined includes explorational and intensive research, as the words have been used in previous discussions of the subject, but it omits the major part of what has been termed "developmental research." The last named is recognized as being primarily a function of the individual engineer and the industrial laboratory. By far the largest part of the work of all the laboratories connected with the industry is of this nature and, as such, it is recognized by the department as being essentially confidential. However, it is coming to be more and more generally recognized that there is much more to be gained than lost through a free interchange of all research information, although we regret, sometimes, to find this more as an abstraction than as a course of action. The Research Department, therefore, will confine its efforts to explorational and intensive fundamental research. Much work of this nature that is in progress in the industrial laboratories will be of interest to the department, and it is hoped that much more such work will be undertaken in the future; but we will not concern ourselves with the major part of the work of these laboratories, which is development work.

Research Personnel Requirements

The true research man is "born, not made." To be a success in any large sense, he must have the advantage of the equivalent of the best scholastic training; otherwise he cannot master the tools of research, which are the correct use of engineering instruments, and the making of precise laboratory measurements and mathematical analyses of results in the light of known physical and chemical facts and laws. He must always know the why of any observed fact. Without the use of these tools, often he will be led to irrational conclusions and costly errors.

These particular requirements appear less important in the experimental development laboratory. Here the *why* is of less importance than the individual fact, and the correctness of the fact must be checked and rechecked by trial. However, an unbelievable amount of time and effort is wasted in the trial of expedients that a more careful application of the fundamental laws of physics and chemistry would show at a glance are based on incorrect assumptions. This fact was startlingly illustrated during the war when thousands of inventions of every conceivable sort were presented for the consideration of the Government. It is safe to say that at least 90 per cent of these proposals showed such obvious and fatal errors in fundamental physical and chemical principles that they could be condemned absolutely, at once; most of them could be condemned equally well on practical grounds, but one's judgment as to practical possibilities is by no means so safe a guide. Many things that look impractical do actually work but, so far as we know, nothing works that violates the law of the conservation of energy, the second law of thermodynamics, Newton's laws of motion, or any other of

[1] M.S.A.E.—Manager, research department, Society of Automotive Engineers, Inc., New York City.

several hundred such principles. Successful engineering research and economical development work require men with a peculiar combination of broad fundamental knowledge and sound commonsense, to which is added the enthusiasm of the typical inventor with his typical shortcomings eliminated.

The Support of Research

The two main incentives that actuate the research man are a thirst for knowledge and the hope of economic progress. So far as the research worker himself is concerned, one can almost neglect the second incentive. A desire for knowledge for its own sake is almost the sole incentive of the individual who will devote his life to fundamental research. If the appeal of commercial success is strong, usually he will drift into invention or development where his research training will make for greater returns in money. However, the most common incentive for the organization and continued support of research laboratories or of any systematic research program is necessarily the commercial. In fact, this is almost the only one if we except some of the educational laboratories that have been endowed purely for the sake of the advancement of science. Thus, almost every research laboratory, particularly the industrial ones, presents a constant conflict between two viewpoints that are somewhat incompatible. The true research-worker is interested in securing facts and will not be satisfied until his results are complete. Moreover, every problem he undertakes presents to him numerous side-lines that are of absorbing interest. If given his own way, he will either carry through his problem to a final conclusion or switch to some side-line of greater interest, according to his temperament, unless he is endowed with unusual self-control. On the other hand, the director of the laboratory or the capitalist who finances it, will, as soon as some fact of apparent commercial value is developed, recommend dropping the research and developing something useful, unless endowed with unusual patience and foresight. A happy medium between the two viewpoints is difficult to attain; but a real compromise is necessary since both viewpoints are important and neither side can be neglected. I believe that the financial manager is coming more and more to realize that the search for knowledge affords the basis for all fundamental economic development in the long run.

Importance of Research

The extent to which scientific knowledge has preceded and formed the necessary basis of later industrial development is remarkable. For instance, practically all phases of the electrical industry owe their inception and development to the results of scientific researches, some of them antedating their application by many years. Faraday, Maxwell, Kelvin and Helmholtz, who laid the foundation for our present knowledge of this subject, probably had not the slightest idea of any possible industrial application of most of their results. Perhaps it is for this reason that the electrical industry has been the first to recognize the importance of the research laboratory and, particularly, the importance of giving to research men a rather free hand in prosecuting researches that have no obvious commercial application. In general, the profits that have accrued from the application of the results of such researches alone probably have exceeded by far the cost of all research supported by this industry.

In the development of the automotive industry in this Country, the field for research has been somewhat less apparent. The few elementary scientific facts that were essential to the origin of the automobile engine were largely forgotten in the course of its experimental development. Other features of design were more the result of development than of fundamental research, as carried on in this Country at least. It has come about therefore that, up to within the past few years, the United States, which has shown by far the greatest industrial development in the automotive line, has contributed comparatively little to the sum of automotive research. The work of British and German experimenters had to serve the needs of our own engineers, even though it was entirely inadequate for these needs. The reasons for this are perhaps more or less obvious. The industry here has been in an unusually favorable situation. It has been more important to manufacture than to improve designs in the direction of economy and efficiency. Compared with the situation in Europe, there has not been the same kind of competition in the details of design, with correspondingly less intense interest in this subject. I believe we can say without question that this period is past, or at least that the conditions have changed decidedly. Considering the various phases of the fuel problem and the general situation with regard to the distribution of automotive appliances, it seems that the engineer must hereafter turn his attention somewhat more to the perfection of details that will obtain fuel economy. This perfection of details necessitates the application of fundamental research results.

A general awakening to the need of research has occurred within the past few years among members of the Society. Its importance has been so ably presented in recent papers and discussions that it is hardly necessary to emphasize this phase of the subject further. We are now awake to the need and, once awakened, the United States will not lag behind. In fact, perhaps a warning is needed in that, while the possibilities of research hardly can be overestimated, the realization of these possibilities in terms of industrial results rests with the engineers in charge of design and development. No matter how many and how able the research engineers are, or how important their conclusions are, these conclusions and their result will be of value only insofar as they are embodied in successful design. Whatever the Research Department of the Society may do, it cannot replace the thought of the individual designer.

Aims of the Research Department

In general, the object of the Research Department is to secure from all possible sources, through concentrated effort, more and better fundamental technical information for the use of the members of the Society, and to make this information more easily available. The distribution of information can be accomplished in several ways. It is hoped from time to time to publish discussions in The Journal of some of the more important general problems, together with references to all sources where research information can be found. By becoming familiar with the work in progress at the various laboratories, it is hoped to secure more general interchanges of information directly between engineers working along the same lines. However, while the department will serve a useful purpose as a convenience in collecting and spreading information, its main and ultimate object will not be attained until the automotive-research facilities of the Country shall have met adequately the needs of the automotive industry. We often

learn of work being undertaken in various laboratories that has been done elsewhere. If the results of previous work have been published, there is very little excuse for repeating it, at least without careful study. In case the previous work has not been published, it can be made of value only by establishing some means of securing a better interchange of information as to what research is in progress at the various laboratories.

The question of whether the department expects to establish a laboratory of its own has been asked many times. This can be answered definitely in the negative, for the time being at least. The reasons are rather obvious. First, establishing a laboratory on an adequate basis would involve a very large expenditure. This fact alone, however, should not prevent planning for such a laboratory in the near future if there were not other and better reasons for not doing so. Fundamental research is in the last analysis almost entirely a question of men rather than of equipment. Many of the most important scientific results have been obtained almost without any laboratory equipment worthy of the name. A study of the research situation in the various laboratories leads to the conclusion that these are even now sadly undermanned, particularly with men of real ability. Establishing a new laboratory could not increase the supply of first-grade research men; it would have to be manned at the expense of existing institutions, and the net result probably would not be increased research. It appears, therefore, that the department can devote its efforts most profitably to assisting existing research laboratories. These laboratories are of three classes, industrial, educational and independent. They occupy altogether different positions in regard to research, and any general plan of research must take account of these differences.

Industrial Laboratories

It is recognized that the prime object of the industrial laboratories, those directly connected with the various manufacturing companies, must always be developmental research. But we hope that there will be accomplished in connection with this an ever-increasing amount of fundamental research work that can be made of general value; such work as deals with general principles rather than with specific questions of design. An excellent illustration of this point is found in A. L. Nelson's paper on the Fuel Problem in Relation to Engineering Viewpoint. While Mr. Nelson's work obviously was undertaken as a development problem, it was handled and the results were analyzed in such a way as to be of utmost general interest and importance. Although it may not seem always permissible to make public so much of the development side of a problem as in this instance, there is without question a very large fund of purely general research data buried in the records of the various automotive laboratories which would be of inestimable value to other members of the Society if it were resurrected and analyzed by the men who have done the work.

It is a very common experience to find one laboratory undertaking a research intended to cover some problem that has been carefully covered elsewhere, although no record of it is available. It is one of the aims of the Research Department to secure the publication or at least a record of such non-confidential general results, so far as possible, and to act as a clearing-house of information on research problems of this character.

The greatest source of scientific research has always been the various educational institutions, unless we revert to the time when research work was done in the monasteries. While this probably is true still, there is no doubt whatever that of late the relative contribution of the schools to research has decreased markedly. Although this may mean that the industrial and various other laboratories, such as those of the Government, have shown a decided increase in number and output, this is a sad state of affairs. Why should not the schools grow and keep pace with other lines of development? The schools are the only sources for the development of research men for the other laboratories.

Industrial Research and the Colleges

The number of students and graduates from the schools has not measurably kept pace with the development of industrial research in outside laboratories. In fact, with some notable exceptions, the amount of instruction and the number of graduates have been increased at the expense of research. In addition, the industrial and other laboratories also have increased at the expense of the research departments of the schools by withdrawing some of the best men. This is a fatal mistake if industry is to continue to progress along scientific lines. Without competent teachers who have the spirit and ability for research, there will be no future supply of graduates with this spirit and ability; and without new personnel neither sound fundamental research nor effective development can proceed.

The many reasons for the present state of affairs are for the most part attributable to conditions beyond the control of any single group of interests. The prime duty of the schools is necessarily teaching and too often this is interpreted to mean turning out graduates. When the number of students increases without a corresponding increase in income to pay teachers, the work of formal instruction takes precedence and research languishes. But, unless the instruction of an engineering or scientific course includes the contact of the student with research men and research methods, there is small chance that he will become a research man himself. Indeed, active and high-grade research in the university and technical school is absolutely essential to the training of men to fill positions in the automotive industrial laboratories. Those in direct charge of our educational laboratories appreciate this most keenly but, mainly, they find it impossible to change conditions. More time for research on the part of teachers, closer contact with the automotive industry so that they will choose the most important problems, and more active moral and financial support from the industry and from the governing boards of the various schools, would improve the situation. An effective effort to maintain the proper relation between research and formal instruction is being made in some universities. The members of the Society can assist along these lines.

To prevent the too great depletion of the educational staffs by the transfer of competent men to industrial laboratories appears more difficult. As the latter have grown in number and importance there has been competition for the best research men, necessarily. The schools cannot compete on the basis of salaries alone and were it not for certain very attractive privileges afforded by the schools, such as freedom from industrial pressure, independence in the publication of results and the personal recognition accorded to a professor, it is doubtful whether there would be any competent research men left in the teaching profession. Even the attractive features of the teaching profession are being extended more and more to industrial-research men. Fortunately, however, there are enough teachers to whom

pure science and unhampered freedom appeal to maintain some of our laboratories on an effective basis.

Research Problems for the Educational Laboratories

The educational laboratory has its own class of research problems. Experimental development, on the one hand, is out of its field and should be discouraged. The first object is to teach principles and methods, not details. On the other hand, problems of very great magnitude, requiring much equipment and years of consistent work, are out of the question except in a few favored institutions, because of the transient character of the staff of student assistants or research fellows that must be depended upon. Between these two extremes, however, is included the major field of industrial or engineering-research problems. For the most part the various laboratories are rather well supplied with problems but, from some institutions where new facilities or new men have become available, there have come requests for suggestions as to problems or general lines of work that might be taken up with advantage. It seems that here is a splendid opportunity for better use of the educational laboratories by the automotive industry. The custom of farming out individual research problems has been followed to some extent by some companies, but there is room for much more of it. The Research Department stands ready to offer any possible assistance in securing greater cooperation of this kind.

Duplication of Research

Much caustic criticism has been offered recently regarding duplication of research. Research is always a matter of duplication and repetition, since no physical fact is ever established except through repeated observation. The individual experimenter must repeat his results many times and, even so, we usually demand several repetitions by independent observers before we are satisfied. One well known scientist has remarked that the mere fact that a phenomenon is repeated 1,000,000 times is no proof whatever that it will be repeated again; that is certainly true unless there is some fundamental law back of it. Hence, much apparent duplication is not only desirable but necessary; but this applies to intelligent duplication only. Not much is to be gained by having several different laboratories working on the same problem, unless each one knows something about what the others are doing. Unnecessary duplication of this kind should be avoided so far as possible, particularly among the educational laboratories.

Since the results of most research are not available in print for months or perhaps years after the work is begun, the most promising means of preventing unnecessary repetition is some central clearing-house for work proposed and in progress. This function the Research Department hopes to fulfill.

General Research Program

One of the important objects of the Research Department is to assist in the development of a more systematic program of research throughout the automotive industry. The formulation of such a program is too much of a problem to be solved for some time to come. It must be built up little by little with the cooperation of all the members of the Society. I hesitate therefore to say very much on this topic. There are, however, two broad general problems that are brought to attention at once by their importance and the insistent demand for immediate information. These are the fuel problem and the highway problem. The former has been occupying our attention to an increasing extent for two or three years. More than 30 technical papers have appeared in THE JOURNAL alone since Jan. 1, 1919, dealing with some phase of the fuel situation, and the majority of them represent independent research. Most of them are valuable and important papers. Also, a considerable number of papers on different phases of the highway problem have been printed in THE JOURNAL during this same period. A bibliographical list covering both of these subjects is appended. It is earnestly recommended that all members who are interested in research reread and study these papers carefully, as they represent the latest thought and research and indicate the present status of the problems; having in mind the particular phases of the subjects that have the strongest appeal in connection with their own personal activities. Attention is called also to the wealth of information contained in the articles quoted from other sources in these issues of THE JOURNAL.

These papers and articles probably represent more suggested new problems than completed ones. For instance, a very important problem has to do with the relation between the end-point or the volatility of fuel and the average fuel-consumption in actual service. To solve this we must know what constitutes the upper limit of volatility and ascertain whether it is the end-point or something else. Prof. R. E. Wilson has brought out something of interest in this respect, but the question is not yet answered. The general problem of how to save fuel offers an unlimited field for discussion and research. Practically none of even the minor problems suggested in this connection has been solved definitely.

The highway problem has received less attention from the automotive industry, partly because its importance seems only to have been recently appreciated and it does not appear at first sight so immediate a problem of the industry. It has been heretofore mainly a matter of "good roads." So far as the passenger car alone is concerned, this may be a more or less correct viewpoint. Considering, however, the broad question of the economics of highway transportation, the problem is distinctly an automotive one. For instance, it is not possible to consider alone the design of a truck to give maximum ton-miles per dollar if it has a road on which to travel, without including also the cost of the highway. So long as registration fees for passenger cars paid for good roads, we were all reasonably content, but as soon as the highway is commercialized, so to speak, some one will be inquiring about the proper distribution of the highway bill among the different classes of traffic. Some answer to this question must be made. Perhaps it is a problem for the road engineer, but the automotive engineer will be very much interested in both the answer and the method of arriving at that answer. The nature of this answer, or the relative license fees that may be based on it, will be a large factor in deciding what sort of truck will be most economical for any given class of service.

General Effect of the Fuel Situation

Returning to the fuel problem, the first question that comes to mind is the general industrial one as to what the probable future of the situation is as regards fuel; that is, what is the relation that the probable supply, quality and price of fuel will have in the general development of the industry as regards design, usage and sales. It is not difficult to arrive at the general conclusion that fuels probably will be higher in price, and not change

very much in quality for some time. As a matter of fact, the automotive industry ought to promulgate a very strong plea for a uniform quality of fuel for some reasonable period of time.

The next questions are in regard to what effect increased fuel prices will have upon the situation in the automotive industry and what the automotive industry can do about it. These are big questions. There has been an enormous amount of discussion on the subject and it seems that the question has been in the main thoroughly covered and the lines of possible improvement thoroughly defined, but one feature of the problem in particular seems not to have been given the consideration it deserves. Perhaps this is because it is altogether too difficult. What is the cause of the apparently unnecessary actual wastage of unburned fuel?

One research appears to have yielded some data on this point. This is the experimental work of A. C. Fieldner and his associates in the Bureau of Mines. The paper by Fieldner, Straub and Jones on Automobile Exhaust Gases and Vehicular-Tunnel Ventilation showed conclusively that about 25 per cent of the gasoline that goes through the engine of the average motor vehicle is not burned but remains as combustible material in the exhaust; and there is plenty of general information that shows the same thing. This is essentially a question requiring statistical research; that is, it requires a knowledge not so much of what can be done in the laboratory, by the experimental engineer on the road, or with any particular kind of equipment under experimental conditions, but of what the average 9,000,000 users throughout the country will do with the average car under average driving conditions. What does the average user demand in the way of acceleration and what will he endure in the way of inconvenience? How must his carbureter be adjusted to satisfy him and how much can he be induced to learn about the saving of fuel? How can it be impressed upon him that fuel economy is necessary? If fuel wastage does not cost him very much, can he still be induced to improve conditions for the sake of society in general? There are many such questions that are out of the line of usual laboratory research, but they are properly research problems. It is true that they involve more or less psychological study, but we are coming to find that nearly everything in industry involves a large amount of this. Psychology is the heart of advertising and sales, and largely the heart of design. I believe we would not go far wrong if we knew a little more about the pyschology of the average driver, because it has a bearing on fuel consumption.

We do not know much about what mixture ratios are necessary to get good performance. F. C. Mock and P. S. Tice have given us some information on that subject. W. S. James, in his paper on the Elements of Automobile Fuel Economy gives some data as to the relation between the ability to accelerate and the average fuel-consumption, but this was only a beginning. These are simply suggested questions. Perhaps about all the Research Department will be able to do for some time is to suggest questions.

Another question that is of interest in this connection is one about which we know practically nothing, namely, What is the effect of what we term the end-point of the fuel on the average consumption throughout the country, and on crankcase dilution? To answer that question we first need to know what the real significance is of the quality that we have tried to define by the use of the term "end-point." We have the distillation curve; the last drop distils over at 437 deg. fahr. if the gasoline meets Government specifications. If it does not, the temperature may be 450 or 460 deg. fahr.; but, actually, that does not tell much about the true characteristics of the less volatile portions of the gasoline. We do not know whether it is the distillation temperature of the *last* fraction or that of the fraction distilling near the 85 or 90-per cent point that is important, in that it most affects the amount of crankcase dilution and the required temperature of the manifold. Prof. R. E. Wilson, of the Massachusetts Institute of Technology, presented at the 1921 Semi-Annual Meeting a more or less informal paper on Condensation Temperatures of Gasoline and Kerosene-Air Mixtures. This has, I believe, a decided bearing on this question. It suggests a rational method of determining the effective upper distillation-range of gasoline. This is a field that I think those who are interested in fuel per se should investigate. Such results should be rechecked in several independent laboratories.

As for the problems of the future, the future of the automotive industry depends on the adaptation of the future car to the future environment. Mr. Nelson's paper, already mentioned, gives some very interesting suggestions along that line. Mr. James' paper on the Elements of Automobile Fuel Economy attempts to give an analysis of some of the various factors that enter into the question of overall economy. However, there has not been much discussion of the underlying problem of what the general type or general trend of design of cars must be that will cause the public to buy in the largest quantities, or rather that will represent the largest total investment on the part of the public in automotive appliances. This is in reality the thing in which the industry as a whole is interested, marketing its product in such a way as to secure the maximum legitimate share of the expenditures of the Country for transportation. That can be done only by a proper relation between the design of the vehicle and the demand of the public. Much the same thing is true of at least a score of phases of the general problem of the relation between the cost and quality of fuel and the trend of design most favorable to success. We have a few partial answers to some of the questions, but few if any that are complete.

Fuel and Highway-Problem Bibliography

The following bibliographical list includes papers that have been published in The Journal, January, 1919, to November, 1921, inclusive, relating to the fuel and to the highway problems.

THE FUEL PROBLEM

April, 1919

Fuel Economy of Automotive Engines; by H. C. Dickinson; p. 227

An Interpretation of the Engine Fuel Situation; by J. E. Pogue; p. 247

More Efficient Utilization of Fuel; by C. F. Kettering; p. 263

June, 1919

Adapting the Fuel to the Engine; by E. W. Dean and J. P. Smootz; p. 495

July, 1919

The Engine-Fuel Problem; by J. E. Pogue; p. 14

November, 1919

Adapting Engines to the Use of Available Fuels; by J. G. Vincent; p. 345

Mixture Requirements of Automobile Engines; by O. C. Berry; p. 364

THE HIGHWAY PROBLEM

The Relation of Motor-Vehicle Transportation to Highway Design

By H. G. Shirley[1]

Washington Section Paper

THE author emphasizes the need for exact data, and for highway-design based thereon, relative to the type and character of construction that shall be used in building highways after the factors of safe wheel and axle loads and the bearing power of subgrades shall have been determined and agreed upon by motor-vehicle builders and highway engineers in concert. Adequate highways will not be possible before this has been accomplished. This idea is elaborated in the interest of effecting highway-construction standardization.

THE past design of highways has been rather uncertain, the selection of the type and thickness of the surfacing having been made by an empirical rule or determined by the judgment of the engineer in charge. Very often a type of surfacing has been used because it had given satisfactory service in some other locality. The engineer believed that the requirements would be no greater on the road under consideration, frequently without any study of the soils composing the subgrade and foundation. In many instances the subgrade and foundation have been of a character entirely different from that of the highway from which the conclusions were drawn.

The highways of the Country are being built without the use of definite mathematical calculations and designs based thereon. The type and character of construction represent the judgment of the engineer in charge, rather than a logical known design. Before the advent of the heavy motor vehicle the surfacing would loosen up in the spring and heave, when the subgrade had become saturated, but the traffic being light and the vehicle having iron tires the surface would be rolled back and reconsolidate as soon as the subgrade had dried out and settled. This would be repeated for a number of years before the surfacing would break up. But when a heavy motor vehicle strikes the surfacing over a saturated and yielding subgrade, it destroys it completely, and the effective service of the highway is greatly reduced and soon destroyed. Conditions have changed so rapidly that it is necessary now that some investigation and study be made of the subgrade so that it can be stabilized and its bearing power determined. This, together with knowledge of wheel and axle loads, will enable the highway engineer to design a slab or surfacing that will have the required strength to carry the specified load safely. Not until these two factors are known will we be able to solve the equation. In the meantime road designing will be erratic and like guess-work.

Highway Construction Standardization

Motor-vehicle builders and users have aimed much unfavorable criticism at the highway engineer because of failures of highways built 10 or 20 years ago. Motor-vehicle designers would not claim that the vehicles sold to the public 10 or 15 years ago are as usable and capable as the vehicles sold today. I can recall the time when motor-vehicle models were changed about every six months, and few remained unchanged longer than a year. Motor-vehicle design has become more stabilized but is changing constantly to meet conditions. The history of the highway is just the same; it occupies the same position relatively as the vehicle.

The motor-vehicle producer and owner would not acquiesce in a plan that would put an unlimited load on their vehicles. They would not adopt as a slogan, build the truck to carry the load, regardless of the limit of its capacity. But the highway engineer is told daily to build highways to carry unlimited loads. No body of men is more interested in controlling the load carried by the vehicle, and properly so, than the motor-vehicle builders and owners. I congratulate them on the position they have taken against overloading the vehicle, but they should not criticize the highway engineer for taking the same position with regard to the highway. It is just as important to carry the principle down to the road surfacing and the subgrade. It is my opinion that in the near future maximum wheel and axle loads will be specified for each class of surfacing. Highway engineers and motor-vehicle producers and owners must work out a logical and economic unit to be operated over the highways of the country, and determine the reasonable wheel and axle loads to be used. When this has been done and the research departments now engaged on the problem shall have determined the bearing power of the subgrade, the highway engineer can proceed to design a surfacing that will carry the specified load throughout the entire year without danger of it being destroyed.

This is the foundation on which we must build, and before such a foundation shall have been determined, the problem of highway design will not be solved and there will be a gross waste of public funds. Aside from the matter of highway bridges, highway engineers are not interested in gross loads. The gross load can be made exceedingly heavy, provided it is distributed over the proper number of axles and wheels. This can be accomplished by using trailers or employing additional axles and wheels under the truck, whichever is more economical, but a limited wheel load must be established and adhered to strictly if the highways of the Country are to be standardized and built so that they will perform the work they are supposed to do without being destroyed.

Subgrade Soils

The soils composing subgrades are very diversified and have numerous characteristics. This makes the problem very complicated. The soils must be classified. Their bearing power must be determined in such a manner that the information can be used by the engineer and the contractor on the work. The problem must be reduced to a practical and simple basis on which the highways of the Country can be built with an assurance of stability. The investigation of soils now being made by the Bureau of Public Roads, leading highway departments and universities, probably will result in some method of deter-

[1]Secretary, Federal Highway Council, Washington.

mining and improving their bearing power, possibly by chemical or mechanical treatment. If so, the unknown quantities will then become known and the engineers will be able to design highways and railroads just as exactly as motor trucks and highway bridges are designed today.

Political Influences

Political interference in highway building makes it difficult to construct a road as it should be constructed. Appropriations are usually made to cover the cost of a highway between two stated points. This may be so great a distance that only by using a very narrow and thin surfacing can the work be done within the appropriation and such a surface is inadequate to meet the traffic conditions of the near future. When the highway engineer is given instructions to build such a highway and to select a type and width that will make the appropriation cover the cost of a road over the entire distance, he must carry out the instructions even when he knows that a great mistake is being made. Such a highway will have only a short life and high maintenance charges and be altogether an economic mistake. These political condiitons are impossible of control and will remain so until public sentiment demands that the building of highways be placed in the hands of men specially qualified to do such work. The highway engineer must gain the confidence of the public in such a way that it will leave much to his own judgment and skill.

Necessary Cooperation and Its Advantages

The highways of the Country are being built just as well as the public demands, and sometimes better. The value of a highway to a community or a State compensates for the cost of its construction and maintenance, even if it render service for only a few years. It is necessary very often to build a road of an inferior type so that it can earn enough money to replace itself with a higher type. The amount saved in operation over an improved as compared with an unimproved highway is such that, if capitalized, a fairly well traveled highway can be resurfaced annually. A further value that cannot be estimated in terms of money lies in the enjoyment and comfort the highway provides its users, in the service it renders to all the people who have access to it and in the abatement of loneliness. Statistics show that the lives of more farmers' wives are wrecked by insanity caused by isolation and consequent loneliness than by any other cause. The accessibility afforded by an improved highway induces contentment and happiness and makes the isolated farm accessible.

The aggregate of the appropriations available and the great amount of money that will be appropriated from time to time make it essential that the design, construction and maintenance of highways be put on a known basis. It is very necessary that designers, producers and owners of motor vehicles cooperate with highway engineers and devise a plan that will provide for a definite wheel and axle load and a maximum speed. When this has been done, the public should be educated to depend upon highway engineers for a thorough study of the traffic and to design highways that will carry present and probable future traffic in the most economical way. The public should realize that such highways will have longer life, perform greater service and eventually be more economical in every way, although their first cost is greater. Unless designers of motor vehicles and highway engineers can agree upon what constitutes reasonable wheel and axle loads, we cannot expect very much improvement in highway work. I trust that they will cooperate to a greater degree soon and thresh this problem out and arrive at a definite conclusion. Then we can proceed with the construction of our highways and know that the money appropriated will be so expended as to render the greatest service.

EXHAUST GAS IN FUEL CHARGE

SINCE internal-combustion engines were first used to drive motor cars, designers have sought to increase the power output per unit of piston displacement and the reliability of the engine. Great progress has been made along these lines, but today it is necessary for the engine to be not only powerful and reliable, but also economical in its fuel consumption.

In the early days of the automobile, a favorite topic for discussion was the influence of the spent gases remaining in the clearance space at the end of the exhaust-stroke. This dilution of the fresh charge was considered to have a bad effect, as evidenced by the number of scavenging devices that were developed. Most of these devices have been discarded and now methods are being suggested for adding exhaust gas to the induction system, thus increasing the amount of inert gas in the cylinder. The engineers' attitude seems to have changed from open hostility to toleration and finally to admiration. The first change is easily explained. Increased power was desired and thorough scavenging made this possible by permitting the introduction of a larger charge.

In adding exhaust gas to the induction system, a higher thermal efficiency has been the goal. Some investigators have found that increasing the amount of inert gas in the charge tends to prevent the fuel knock and therefore enables a high compression-ratio to be employed. Since thermal efficiency depends upon the expansion-ratio, which in the conventional engine equals the compression-ratio, it should be higher with a higher compression-ratio. Full-throttle tests apparently show this to be the case and from these results it has been concluded that the addition of exhaust gas will be even more beneficial at part-throttle. It is assumed that under such conditions a decrease in power is of no consequence and that the heat of the exhaust may be of considerable aid in vaporizing the fuel. Since in service the automobile engine is operated at part-throttle most of the time, it is under this condition that economy of fuel consumption is most important.

Nearly all investigators have noted that under light loads the engine will not fire mixtures having as high a ratio of air to fuel as that which gives the best economy at higher loads. This is probably because the inert gas with a partially open throttle forms so large a proportion of the total charge. The compression-pressure also is, of course, too low; many experimenters have ascribed the poor efficiency to this cause. To prove that the proportion of the exhaust gas is the predominant influence, an engine partly throttled was operated with the leanest air-fuel ratio with which it would fire regularly. The engine was again operated with a sufficient amount of exhaust gas admitted with the charge to reduce the engine power to the same value as had been obtained in the first test by throttling. Although the pressures in the latter case were considerably higher than before, not nearly as high an air-fuel ratio could be fired.

It seems fair to conclude, therefore, that the dilution of the charge by the spent gases remaining in the clearance volume makes it impossible at low throttles to employ those air-fuel ratios that if they could be fired would yield the maximum efficiency. If the exhaust gas that is present during normal operation forms a barrier to the use of high-efficiency mixtures, surely the designer ought to avoid any devices for adding still more dead gas to the charge.—Bureau of Standards Bulletin.

ACTIVITIES OF THE SECTIONS

Sections Calendar

BUFFALO
(Secretary—George H. Pettit, 1569 Jefferson Street, Buffalo)
Jan. 17—Pneumatic Truck Tire Temperatures. —Professor Ellenwood

CLEVELAND
(Secretary—E. W. Weaver, 5103 Euclid Avenue, Cleveland)
Dec. 16—Aviation Meeting—Speaker, Glenn L. Martin

DAYTON
(Secretary—R. B. May, Dayton Engineering Laboratories, Dayton)
Jan. 17—Lubrication.—Dr. H. C. Dickinson

DETROIT
(Assistant Secretary—Mrs. B. Brede, 1361 Book Building, Detroit)
Dec. 5—Aviation Dinner to Admiral William F. Fullam
Dec. 16—Light-Weight Pistons

INDIANA
(Secretary—B. F. Kelly, Weidely Motors Co., Indianapolis)
Dec. 12—Aviation Meeting

METROPOLITAN
(Secretary—F. E. McKone, 347 Madison Avenue, New York City)
Dec. 15—Aviation Meeting — Speakers, Ralph Upson, C. M. Manly, C. F. Redden and S. H. Philbin

MID-WEST
(Secretary — Taliaferro Milton, 140 South Dearborn Street, Chicago)
Dec. 29—The Laws of Thermodynamics.—Prof. C. A. Norman
Feb. 3—The Constitution of Matter.—Prof. H. B. Lemon
March 31 — Various Commercial Fuels and their Relative Characteristics

MINNEAPOLIS
(Secretary—C. T. Stevens, 13 South Ninth Street, Minneapolis)
Dec. 7—A Safety High-Pressure Boiler for Use in Automobiles.—Charles B. Page
The Bissell Caterpillar Stump Puller —E. F. Norelius.
The Engineering Field — Dr. C. A. Prosser

NEW ENGLAND
(Secretary—H. E. Morton, B. F. Sturtevant Co., Hyde Park, Boston)
Dec. 16—Aviation Meeting at Boston—Speaker, Prof. E. P. Warner
Jan. 13—Visit to Stanley Plant in Newton

PENNSYLVANIA
(Secretary—T. F. Cullen, Chilton Co., Market and 49th Streets, Philadelphia
Dec. 22—Aviation Meeting — Speakers, Ralph Upson, W. B. Stout and Assistant Postmaster-General Shaughnessy

WASHINGTON
(Secretary — Benjamin R. Newcomb, Victor Bldg., Ninth and G Streets, City of Washington)

ST. LOUIS EXTENSION MEETING
Dec. 1—Trend of Aviation Development. — J. G. Vincent

THE Buffalo Section held its first fall meeting on Nov. 15 in the rooms of the Buffalo Engineering Society at the Iroquois Hotel. R. W. A. Brewer gave a paper on the design of inlet-manifolds and the fundamental bases governing their dimensions. He described the method of determining the rate of heat transfer and discussed the evils of poor distribution.

The Cleveland Section held its first meeting of the season in the rooms of the Cleveland Engineering Society at the Hotel Winton on Oct. 21, about 80 members being present. The dinner preceding the technical session was attended by several members of the Council of the Society, including President Beecroft, who outlined the plans of the Society for the coming year.

H. A. Schwartz presented a paper on malleable cast iron, touching upon its history, manufacture and physical properties. He described in particular some recent drilling-speed tests that he had conducted.

The paper on lubrication by Dr. H. C. Dickinson that was scheduled for the meeting of the Dayton Section on Dec. 6, will be presented on Jan. 17.

The Detroit Section on Dec. 5 gave an Aviation Dinner to Admiral William F. Fullam in conjunction with the local Aviation Society and Board of Commerce, at which Past-President C. F. Kettering was toastmaster. The regular meeting of the Section will be held on Dec. 16 at which the subject of Light-Weight Pistons will be discussed.

The various basic principles underlying the design of several types of carbureters were described at the Detroit Section meeting of Oct. 28. The speakers were D. W. Kriedler, S. E. Taylor, E. H. Shepard and F. R. Perry.

The Indiana Section will hold an Aviation Meeting on Dec. 12, at which a number of prominent officials from McCook Field are expected to be present.

C. T. Myers gave some startling figures at the Metropolitan Section meeting on Nov. 17 regarding the probable proportions of replacement costs attributable to insufficient chassis lubrication.

The first of the excellently planned series of sessions on the thermodynamic theories upon which all engine design is or should be based was held at the rooms of the Western Society of Engineers on Oct. 31. Prof. Daniel Roesch spoke on Power Fundamentals and gave a classroom explanation of the terms and units used. The educational program of the Mid-West Section should be appreciated thoroughly by those members who covered the subjects indicated in their younger days and have since forgotten a large part of them, and by those who have not had previously the opportunity of learning the ground-work so necessary for intelligent design. The second talk of this series was given by P. S. Tice on Nov. 25. His subject was the vaporization of fuels and other phenomena.

Prof. C. A. Norman will discuss on Dec. 29 the laws of thermodynamics.

Two technical papers and a talk on the economic situation were given before the Minneapolis Section on Nov. 2. A. H. Bates had as a subject the power absorption in tractors from the engine to the ground. Prof. A. F. Moyer discussed rotative balance. F. E. Kenaston spoke of the relation of the banker to the automotive industry.

On account of his removal to New York City, where he is now engaged as manager of the Research Department of the Society, the Washington Section was forced to accept Dr. Dickinson's resignation as its chairman. The activities of the Section will be directed by Vice-Chairman F. H. Pope as administrative head during the rest of the season. Benjamin R. Newcomb has been elected secretary of the Section to succeed Archibald Black, who moved his office to New York City. At the meeting held on Nov. 4 M. E. Cheney spoke on recent spark-plug developments, explaining the theories upon which the design of spark-plugs for different conditions of operation is based. H. S. McDewell gave an account of his experience with the Ricardo supercharging engine, showing slides by way of illustration.

Many of the Sections have arranged to hold meetings on

various phases of aviation. The dates of these, so far as they have been decided upon at this writing, are given in the Sections Calendar. An article on what it is hoped to accomplish at these meetings appears elsewhere in this issue of THE JOURNAL.

At a meeting of the Pennsylvania Section held on Nov. 22, two very interesting papers were presented. The latest developments in the fuel situation were discussed by Thomas Midgley, Jr., and T. Orchard Lisle, editor of *Motorship*, New York City, spoke very entertainingly on modern Diesel engines and motorships. The latter paper was supplemented by numerous lantern slides showing typical applications.

NATIONAL MEETINGS OF THE SOCIETY

A RECENT issue of the Meetings Bulletin described in considerable detail the programs arranged for the several national meetings of the Society which will be held this winter. For this reason it is unnecessary to record anything but a brief outline of the plans in this issue of THE JOURNAL. The descriptions of the meetings are given in sequence.

THE CHICAGO FUEL MEETING.

In response to an invitation from the American Petroleum Institute, the Society has arranged to conduct two technical sessions on the matter of fuel uniformity during the convention of this organization of petroleum refiners at Chicago, Dec. 6 and 7. The meetings will be held in the Congress Hotel and will start promptly at 10 o'clock.

The program follows:

TUESDAY, DEC. 6

Quantitative Survey of the Petroleum Industry from the Standpoint of Production of Internal-Combustion Engine Fuel—Van H. Manning

Quantitative Survey of Automotive Engine Fuel Requirements — E. S. Jordan, of National Automobile Chamber of Commerce

Requirements of Motor Vehicle Fuel—H. M. Crane

Qualitative Limitation in Refining and Marketing—F. A. Howard

Volatility of Motor Fuel as Marketed in the United States—N. A. C. Smith

What Constitutes True Volatility?—Robert E. Wilson

Present Variations in Quality of Internal-Combustion Engine Fuel, Its Extent and Causes—C. K. Francis

WEDNESDAY, DEC. 7

Research Discussion

Limitations Imposed on Economy by Volatility Changes—F. C. Mock

Practical Effects of Too Low Volatility—O. C. Berry

THE ANNUAL MEETING.

The Annual Meeting of the Society will be held in New York City, Jan. 10-13, 1922. During this four-day period there will be eight technical sessions, the annual meeting of the Standards Committee, the business meeting of the Society and election of officers, the Dinner at the Hotel Astor and the Dance Carnival at the Hotel Pennsylvania. Harry Ricardo, the eminent British automotive engineer, will present a paper at the technical session on Thursday, Jan. 12, in which he will assemble the results of his extensive automotive research work for discussion by our members.

The schedule of events for the Annual Meeting follows:

TUESDAY, JAN. 10.

Morning—Standards Committee Meeting
Afternoon—Standards Committee Meeting
Evening—Aeronautic Session

WEDNESDAY, JAN. 11.

Morning—Annual Business Meeting
Election of Officers
Afternoon—Body Engineering Session
Motor Truck Transportation Session
Lubrication Session
Evening—Dance Carnival, Hotel Pennsylvania

THURSDAY, JAN. 12.

Morning—Research Session, Mr. Ricardo
Afternoon—Fuel and Engine Session
Automotive Materials Session
Evening—Annual Dinner, Hotel Astor

FRIDAY, JAN. 13.

Morning—Passenger Car Session

Preprints of the papers to be read at the Annual Meeting will be mailed only to those members requesting them. An application blank for ordering preprints was mailed to the entire membership with the last issue of the Meetings Bulletin.

THE CHICAGO MEETING.

The annual Chicago Meeting of the Society will be held in that city, Feb. 1, 1922. There will be two technical sessions, one in the morning and the other in the afternoon. Both of these technical meetings will be conducted at the Chicago Automobile Club and will be devoted principally to matters concerning operation and maintenance. The Chicago Dinner has been arranged at the Hotel Drake on the evening of the same day at 6.30 o'clock.

THE TRACTOR MEETING.

The Annual Tractor Meeting of the Society, which is held each year in conjunction with the National Tractor Show, will be convened in Minneapolis, Feb. 8 and 9. There will be two technical sessions devoted to tractor subjects, these being held during the afternoons of the two days noted. On Thursday evening, Feb. 9, the Annual Farm Power Dinner will be served. The location of the meetings and the dinner has not been determined at this date, but will be included in future meeting announcements. The Minneapolis Section will assist in the conduct of this Tractor Meeting and with their cooperation it is expected that an attractive technical program will be arranged.

OBITUARIES

JAMES CHASE RAPPLEYEA, service director for the Bethlehem Motor Corporation, Allentown, Pa., died Oct. 24, 1921, aged 43 years. He was born Dec. 19, 1877, at Rochester, N. Y., and was educated in the public schools there. He was owner of an automobile repair business in New York City from 1903 to 1906 and then, until 1911, was superintendent of automobile repairs for the O. J. Gude Co. in New York City. Becoming shop foreman for the Chalmers Motor Co. in 1911, he continued this work until 1916 and then was foreman and assistant to the service manager, progressively, for the Willys Overland Co., in New York City. Mr. Rappleyea became service director for the Bethlehem Motor Corporation in 1920. He was elected to Associate member grade in the Society March 25, 1918.

WILLIAM J. WALSH, assistant sales manager for the Buda Co., Harvey, Ill., died, Aug. 31, 1921, aged 51 years. He was born, Feb. 3, 1870, at Chicago. Following his common school education he received training along commercial lines and entered the employ of the Buda Co. about 1910. There he gained considerable experience in shopwork and later became identified with the sales department. He was elected to Associate member grade in the Society, June 21, 1917.

Applicants *for* Membership

The applications for membership received between Oct. 21 and Nov. 23, 1921, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ACKERMAN, PAUL CEDRIC, student, University of Michigan, *Ann Arbor, Mich.*

ALTHOUSE, ANDREW D., instructor, Cass Technical High School, *Detroit.*

BAMFORD, GEORGE F., instructor in ignition, starting and lighting, Motor Transport Training School, *Camp Holabird, Md.*

BAUMAN, JOHN NEVIN, student, University of Michigan, *Ann Arbor, Mich.*

BAYCROFT, LOUIS B., manager Boston service depot, Electric Storage Battery Co., *Philadelphia.*

BENTON, EDWARD L., service manager, Benton Electric Co., *LaCrosse, Wis.*

BLACK, GEORGE ANGLIS, JR., student, University of Michigan, *Ann Arbor, Mich.*

BOCK, OSCAR LOUIS, student, Iowa State College, *Ames, Iowa.*

BOYD, GEORGE W., proprietor, Boyd's Garage, 129 Brock Street, *Kingston, Ont., Canada.*

BURGER, GEORGE EDWIN, JR., student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

BORRESON, HARRY, foreman, practical test laboratory, American Bosch Magneto Corporation, *Springfield, Mass.*

BRENNER, CLYDE A., treasurer and general manager, Brenner Automobile Supply Co., *St. Louis.*

CARLSON, AMEL R., vice-president and general manager, Commonwealth Motors Co., *Chicago.*

CARLSON, R. E., chief of tank section, tank, tractor and trailer division, Ordnance Department, *City of Washington.*

CARTER, THOMAS FREDERICK, JR., student, Georgia School of Technology, *Atlanta, Ga.*

CLINE, EARL E., chief engineer and superintendent, Ernest Holmes Co., *Chattanooga, Tenn.*

DEMPSEY, WILLIAM L., consulting engineer and president, Dempsey Cycle Co., *Philadelphia, Pa.*

DIEDERICHS, H., director of school of mechanical engineering, Cornell University, *Ithaca, N. Y.*

DRAPER, HOWARD W., supervisor of automotive courses, Franklin Union, 41 Berkeley Street, *Boston.*

DURLAND, HARRY S., instructor, Pratt Institute, *Brooklyn, N. Y.*, and salesman, Double Seal Ring Co., 1834 Broadway, *New York City.*

EASTMAN, EDWARD HUNT, student, Iowa State College, *Ames, Iowa.*

FITZPATRICK, JAMES R., secretary, Haskelite Mfg. Corporation, 133 West Washington Street, *Chicago.*

FLORO, MARTINIANO, student, University of Illinois, *Urbana, Ill.*

FRANCIS, C. K., chief chemist and technical superintendent, Cosden & Co., *Tulsa, Okla.*

GAA, VICTOR H., model maker, Edmund & Jones Corporation, *Detroit.*

GAGER, JOHN B., service manager, American Motor Truck Co., *Newark, Ohio.*

GANSTER, LOUIS T., president and general manager, Berks Auto-Ignition Co., 514 Cherry Street, *Reading, Pa.*

GELPKE, ADOLF, chief draftsman, Autocar Co., *Ardmore, Pa.*

GOOD, CHARLES WINFRED, instructor, University of Michigan, *Ann Arbor, Mich.*

GUTEKUNST, HERMAN, assistant chief engineer and assistant general manager, Ray Battery Co., *Ypsilanti, Mich.*

HALLADAY, MERTON EMERSON, student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

HAMILTON, ERWIN, instructor, New York University, University Heights, *New York City.*

HARRY, GORDON W., student, University of Michigan, *Ann Arbor, Mich.*

HART, RICHARD LECKLIDER, student, University of Michigan, *Ann Arbor, Mich.*

HEDRICH, O. H., JR., student, University of Illinois, *Urbana, Ill.*

HOPKINS, FRED J., student, Georgia School of Technology, *Atlanta, Ga.*

HOUSER, JESSE E., chief inspector, Delco-Light Co., *Dayton, Ohio.*

HOWELL, K. J., 802 Ocean Avenue, *New London, Conn.*

LATHEM, JOSEPH GAULT, JR., student, Georgia School of Technology, *Atlanta, Ga.*

LINDSTROM, CARL T., student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

LITTLEFIELD, L. H., engineer, Barnsdall Refining Co., *Kansas City, Mo.*

LOVEJOY, RALPH M., president, Lovejoy Mfg. Co., *Boston.*

MCMAHON, ROBERT A., manager, Boyd's Garage, 129 Brock Street, *Kingston, Ont., Canada.*

MALONE, D. G., student, University of Illinois, *Urbana, Ill.*

MURPHEY, JOHN EDMUND, 2ND, student, Georgia School of Technology, *Atlanta, Ga.*

NEUHART, J. H., general manager, Liggett Spring & Axle Co., *Monongahela, Pa.*

POWER, E., superintendent of equipment, Union Oil Co., *Los Angeles, Cal.*

RICH, RALPH E., president and chief engineer, Amalgamated Metals Co., *Chicago.*

RIPLEY, JOSEPH P., general manager, Brewster & Co., Bridge Plaza, *Long Island City, N. Y.*

ROEMER, ARTHUR, designer, Hupp Motor Car Corporation, Mount Elliott & Milwaukee Avenues, *Detroit.*

ROOKS, ALFRED WENDELL, student, School of Engineering, *Milwaukee.*

ROSECRANS, CRANDALL Z., research assistant in mechanical engineering, University of Illinois, *Urbana, Ill.*

ROWELL, HENRY SNOWDEN, director of research, Research Association of British Motor & Allied Manufacturers, *London, England.*

RUGE, EDGAR P., road service man, Dorris Motor Car Co., *St. Louis.*

SACKETT, A. H., service manager, Elgin Motor Car Corporation, 54 East 51st Street, *Chicago.*

SCHROYER, E. C., instructor in automotive engineering, Georgia School of Technology, *Atlanta, Ga.*

SCHWARTZ, CHRISTIAN, testing engineer, Studebaker Corporation of America, *Detroit.*

SEMINO, ANGELO F., student, Leland Stanford Junior University, *Stanford University, Cal.*

SHARON PRESSED STEEL CO., *Sharon, Pa.*

SHRIVER, LIEUT. E. F., in charge of motor transport unit, Georgia School of Technology, *Atlanta, Ga.*

SODERHOLM, CAPT. WALTER H., Ordnance Department, *Rock Island Arsenal, Ill.*

SPRIGGS, CECIL T., student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

STALNAKER, R. H., assistant highway engineer, California Highway Commission, Forum Building, *Sacramento, Cal.*

STROEBEL, GEORGE ARTHUR, student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

STROHL, GEORGE RALPH, mechanical engineer, Autocar Co., *Ardmore, Pa.*

STURTEVANT, FOSTER E., draftsman, Ward Motor Vehicle Co., *Mount Vernon, N. Y.*

SVENSON, CHARLES W., mechanical superintendent, Corbin Screw Corporation, *New Britain, Conn.*

TERHUNE, JOHN E., superintendent, Cox Brass Mfg. Co., *Albany, N. Y.*

TETHER, CLIFFORD F., student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

TIFFANY, HALSTED R., student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

TITCHENER, WALTER E., production manager and engineer, Cortland forging division, of Brewer-Titchener, *Cortland, N. Y.*

TRAMMELL, LEANDER NEWTON, student, Georgia School of Technology, *Atlanta, Ga.*

ULRICH, THEODORE, layout draftsman, Hupp Motor Car Corporation, *Detroit.*

VIETS, ELTON WILLARD, student, University of Michigan, *Ann Arbor, Mich.*

WHITTLESEY, F. E., manager, Raymond Mfg. Co., Ltd., *Corry, Pa.*

WILLIAMSON, JOHN EARL, student, Rensselaer Polytechnic Institute, *Troy, N. Y.*

WRIGHT, WARREN O., assistant chief engineer, Bowen Products Corporation, *Auburn, N. Y.*

ZEDER, JAMES C., student, University of Michigan, *Ann Arbor, Mich.*

Applicants Qualified

The following applicants have qualified for admission to the Society between Oct. 10 and Nov. 10, 1921. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

Allison, First-Lieut. Philip W. (S M) Eighth Field Artillery, Schofield Barracks, *Hawaii.*

Anderson, A. E. (A) garage foreman, Standard Oil Co., *Spokane, Wash.*, (mail) 211 South Ralph Street.

Anderson, F. W. (M) vice-president and general manager, Northwestern Motor Co., *Eau Claire, Wis.*

Bartlett, Percy H. (A) machine shop superintendent, Sinclair Refining Co., Chicago, (mail) 108 South Scoville Avenue, *Oak Park, Ill.*

Berliet, Marius (F M) general manager, Societe des Automobiles M. Berliet, *Lyons, France.*

Chambers, F. W. (E S) 45 Cecil Street, *Toronto, Ont., Canada.*

Dames, Gust A. (A) mechanical engineer, 255 West 52nd Street, *New York City.*

Danville Malleable Iron Co. (Aff) *Danville, Ill.*
Representative: Smith, William C., assistant general manager.

Dennis, Henry A. (A) supervisor of motor equipment, Texas Co., 201 Devonshire Street, *Boston.*

DeWaide, Hal (J) sole owner and designer, Hal DeWaide "Sport Car," 434 West Salmon Street, *Portland, Ore.*

Doten, Everett F. (J) engineering department, Muskegon Motor Specialties Co., *Muskegon, Mich.*

Evans, Clark (E S) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 1218 Washtenaw Avenue.

Fish, Melvin L. (J) automotive designer, Fox Motor Car Co., *Philadelphia*, (mail) 5718 North Sixth Street.

Flage, John E. (A) superintendent of manufacturing, Ray Battery Co., *Ypsilanti, Mich.*, (mail) 608 Pearl Street.

Foster, Ernest H. (M) mechanical engineer, *Dongan Hills, Staten Island, N. Y.*

Hanover, H. T. (A) president and general manager, Apex Motor Co., *Ypsilanti, Mich.*

Herrick, Edward D. (M) assistant chief engineer, Lycoming Motors Corporation, *Williamsport, Pa.*

Holmes, F. E. (A) head machinist, Walter M. Murphy Motors Co., *Pasadena, Cal.*, (mail) 202 West Walnut Street.

Kershow, W. V. (A) Overland Syracuse Co., Syracuse, N. Y., (mail) 324 Greenwood Place.

Kubacka, Joseph E. (J) body engineer, Victor Page Motors Corporation, *New York City*, (mail) 1073 First Avenue.

Lindsay, H. O. (A) chief engineer, department of internal-combustion engines, Pure Oil Co., *Minneapolis*, (mail) 1302 First Street, South.

Loupret, Lionel N. (M) electrical engineer, Kokomo Electric Co., *Kokomo, Ind.*, (mail) 14 West Elm Street.

MacNab, F. B. (A) business manager, General Motors Research Corporation, *Dayton, Ohio.*

McKinley, William A. (M) chief engineer, Detroit Pressed Steel Co., 6660 Mount Elliot Avenue, *Detroit.*

Meeson, William P. (F M) works manager, Arrol-Johnston, Ltd., Dumfries, (mail) Westbourne House, *Maxwelltown, Scotland.*

Mitchell, G. I. (M) assistant professor of mechanical engineering, University of Wisconsin, *Madison, Wis.*, (mail) 97 South Warren Street.

Moran, Charles B. (J) chief engineer, American Die & Tool Co., Second and Buttonwood Streets, *Reading, Pa.*

Montanye, James (A) service manager, General Motors, Ltd., 1 Thurloe Place, *London, S. W. 7, England.*

Reid, Albert R. (M) chief chemist, U. S. Light & Heat Corporation, *Niagara Falls, N. Y.*, (mail) 354 First Street.

Rogers, James B. (A) experimental engineer, Joy Ball Bearing Co., *Chicago*, (mail) 457 North Racine Avenue.

Runyan, William B. (A) vice-president and general superintendent, Dayton Malleable Iron Co., *Dayton, Ohio*, (mail) P. O. Box 980.

Smith-Clarke, George Thomas (F M) assistant works manager, Daimler Co., Ltd., Coventry, (mail) "Glenroy" Waverley Road, *Kenilworth, England.*

Stuart, C. C. (A) sales engineer, Soss Mfg. Co., Brooklyn, N. Y., (mail) 535 Book Building, *Detroit.*

Tanaka, Capt. Tatsuzo (F M) Imperial Japanese Navy, Hiro-Shisho, *Kure-Kaigun-Kosho, Japan.*

Tietz, Paul C. (J) chief draftsman, H. C. Saal Co., *Chicago*, (mail) 1646 Byron Street.

Tucker, John J. (S M) aeronautical mechanical engineer, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

Underwood, Arthur J. (E S) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 1014 Cornwell Avenue.

Webster, J. Ordway (A) test pilot, air mail service, Post Office Department, City of Washington, (mail) Hotel Edward, *Maywood, Ill.*

Work, Robert Van-Horn (J) Baker Steam Motor & Mfg. Co., *Pueblo, Col.*, (mail) "Woodcroft."

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

INDEX TO VOLUME IX, JULY-DECEMBER, 1921

THE

JOURNAL
OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Published by the Society of Automotive Engineers, Inc., 29 *W. 39th St., New York*

Issued monthly, 50 cents a number, $5 a year; foreign $6 a year; to members, 25 cents a number, $2.50 a year. Entered as second-class matter, Aug. 23, 1917, at the post office at New York, N. Y., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized on Aug. 2, 1918.

David Beecroft, *President* — Coker F. Clarkson, *Secretary* — C. B. Whittelsey, *Treasurer*

Vol. IX — DECEMBER, 1921 — No. 6

INDEX


KERITE
A product of over fifty years distinguished service in the most important electrical fields, possessing inherent characteristics which make it pre-eminently desirable for *High Tension Automotive Ignition*
DAYS KERITE
KERITE
INSULATED WIRE & CABLE
COMPANY
NEW YORK CHICAGO
KERITE
COMPANY

Personal Notes of the Members

Items regarding changes in business connections, promotions, etc., are desired from the membership for insertion in these columns. This will enable members to keep their friends informed of their whereabouts and will also assist in keeping the records of the Society up to date.

Prof. C. A. Adams, until recently chairman of the engineering division of the National Research Council, New York City, has resumed his duties as Lawrence professor of electrical engineering at Harvard University, Cambridge, Mass.

F. G. Alborn, formerly chassis engineer for Hare's Motors, Inc., Bridgeport, Conn., has been made chief engineer for the American Motor Truck Co., Newark, Ohio.

C. S. Ash has opened an office for the practice of automotive engineering at 5718 Russell Street, Detroit. He was previously vice-president of the Detroit Wheel Corporation, Detroit.

Floyd E. Badger, who for the past 10 months has been a member of the sales-engineering staff of the Detroit Steel Products Co., Detroit, has been appointed sales manager of the chassis spring division of that organization. From 1910 to 1918 he was manager of the spring plant of the Standard Parts Co., at Flint, Mich., and during the war he was in charge of production at Motor Transport Corps base repair shops at Camp Holabird, Md. Following his discharge from Government service Mr. Badger returned to the Standard Parts Co. as manager of its Perfection Spring plant at Cleveland.

William R. Beckman has been elected vice-president in charge of engineering of the recently organized Richelieu Motor Car Corporation, Asbury Park, N. J. He was for many years assistant to Fred S. Duesenberg and prior to that was chief engineer of the Loew-Victor Engine Co., Chicago.

E. A. Blake has severed his connection with the Transport Truck Co., Mount Pleasant, Mich., where he was in charge of the experimental department. He has not announced his plans for the future.

Lloyd J. Bohan is now connected with the Chicago office of the Wisconsin Parts Co., Oshkosh, Wis., having severed his connection with the Union Motor Truck Co., Chicago.

Alfred C. Boock is no longer layout draftsman for the Waterloo Gasoline Engine Co., Waterloo, Iowa, but holds a position as designer with the St. Cloud Truck Co., St. Cloud, Minn.

Raymond F. Buckley, who has for the last year been doing patent and consulting engineering work, has become associated in a similar capacity with Robert H. Hassler, Inc., Indianapolis, Ind.

C. W. Butterfield is no longer sales manager for the Herschell-Spillman Motor Co., North Tonawanda, N. Y., but now holds a similar position with the Apex Motor Corporation, Ypsilanti, Mich.

Everett J. Cook, who was formerly chief engineer of the Oklahoma Auto Mfg. Co., Okay, Okla., has organized the

(*Continued on page 4*)

Personal Notes of the Members

Continued

firm of Everett J. Cook & Co. The company, which has its offices in the Nicholas Building, Toledo, is offering its services as engineers, purchasing agents and traffic managers to industrial establishments.

M. H. Cook has resigned as machine designer in the engineering experiment station at the University of Illinois, Urbana, Ill., and has accepted a position as chief draftsman with the Beneke & Kropf Mfg. Co., Chicago.

Charles S. Crawford has been appointed consulting engineer for the Cole Motor Car Co., Indianapolis. He was formerly vice-president in charge of engineering for the Premier Motor Corporation, also of Indianapolis.

C. W. Curtiss, formerly general manager of the Splitdorf Electrical Co., Newark, N. J., and later president and general manager of the Van Sicklen Speedometer Co., also of Newark, until its sale to the Stewart-Warner Speedometer Corporation, has been elected president of the Tiffany Mfg. Co., 50 Spring Street, Newark.

S. F. Delvin is no longer connected with the Government division of the Holt Mfg. Co., Stockton, Cal., as chief draftsman. He has not announced his plans for the future.

James E. Diamond, formerly sales manager and a member of the firm of Walker M. Levett Co., New York City, has become general manager of the National Piston Co., 347 Madison Avenue, New York City.

Clyde E. Dickey has been appointed sales representative for the Metropolitan district for the Peerless Drawn Steel Co., Massillon, Ohio, with headquarters at New York City.

James Dykstra has severed his connection with the Oakland Motor Car Co., Pontiac, Mich., and is now affiliated with the Dare Aircraft Co., Detroit.

A. J. Fitzgibbons is no longer traveling salesman for the Merchant & Evans Co, Philadelphia. but has been elected chairman of the board of directors of the McDermott Steel Corporation, Buffalo, N. Y.

R. P. Flower has been elected vice-president of the Federal Automotive Sales Co., Chicago.

Herbert J. Graham has been made sales engineer for the Electric Service Supplies Co., Philadelphia.

T. G. Graham, formerly factory manager for the Inland Rubber Co., Chicago, is now connected with the Mason Tire & Rubber Co., Kent, Ohio.

George A. Hack, until recently assistant metallurgist with the Champion Ignition Co., Flint, Mich., is now associated with Don W. Coy, consulting engineer, 1227 East 75th Street, Chicago.

A. W. S. Herrington has been appointed engineer of the Motor Transport Division of the office of the Quartermaster General of the Army, City of Washington, succeeding W. T. Norton, Jr., who resigned last February. Mr. Herrington was formerly assistant chief engineer of the Harley-Davidson Motor Co., Milwaukee.

Bradford B. Holmes has opened an office as industrial engineer at 95 Liberty Street, New York City. He was formerly chief engineer for Miller Reese Hutchison, Inc., New York City.

Floyd B. Hubbard, chief engineer and production manager of the tractor department of the Parrett Tractor Co., Chicago Heights, Ill., has severed his connection with that company. His future plans have not been announced.

(*Continued on page 6*)

Personal Notes of the Members

Continued

Herbert S. Jandus has accepted a position as engineer for the C. G. Spring Co., Kalamazoo, Mich.

Roy F. Johnson, until recently sales engineer for the Iron Mountain Co., Chicago, has become affiliated with the Atlantic Die-Casting & Mfg. Co., also of Chicago, in a similar capacity.

George W. Kerr has severed his connection with the H. & M. Body Corporation, Racine, Wis. He has not announced his plans for the future.

Robert A. Klossner has accepted a position as machinist for the MacDonald Steam Automobile Corporation, Garfield, Ohio.

G. J. Lang, formerly assistant to the president of the American Bosch Magneto Corporation, Springfield, Mass., has become affiliated with Gray & Davis, Inc., Boston.

William F. Legg is doing development work on a portable saw outfit for sawing trees and logs for the Chain Saw Co., New York City.

Otto L. Lewis has joined the tool design department at the tractor works of the International Harvester Co., Chicago, as engineer.

Henry G. McComb has accepted a position as sales engineer for the American-La France Fire Engine Co., 250 West 54th Street, New York City.

G. C. McMullen has been transferred from San Francisco, where he was acting as sales engineer for the Timken Roller Bearing Co., to Canton, Ohio, where he will be manager of the industrial bearings division of that company.

Joseph A. Mackle has become re-associated with the Daimler Co. in the capacity of director and manager of Stratton-Instone, Ltd., which has taken over the Daimler branch in London. In 1908 he entered the service of the Daimler organization, leaving in 1914 to become director and general manager of the Willys-Overland, Ltd., London.

Carl T. Mason has accepted a position as chief engineer for the Tiffany Mfg. Co., Newark, N. J. He formerly held a similar position with the Splitdorf Electrical Co., also of Newark.

C. G. Mills is now associated with the Alemite Shop, Wichita, Kan.

Clinton E. Morgan, assistant general manager of the Brooklyn City Railroad Co., Brooklyn, N. Y., was elected general manager at a recent meeting of the board of directors. In his new post Mr. Morgan will be in control of the operation of all the street railway lines operating in the boroughs of Brooklyn and Queens, New York City.

J. S. Murphy has been elected vice-president of the Kelly Valve Co., Chicago. He was formerly associated with the Society of Industrial Engineers, also of Chicago.

Emanuel Nides is no longer chief engineer for the Standard Steel & Bearings, Inc., Philadelphia. His plans for the future have not been announced.

C. A. Obermaier has severed his connection with the Southern Motors Mfg. Association, Ltd., Houston, Tex., as chief engineer and production manager, and has taken over the exclusive sales rights for the State of California for uradia, and is doing business under the name of the California Uradia Sales Co., Los Angeles.

M. Olbeter has accepted a position as designer for the Lawrance Aero-Engine Corporation, 644 West 44th Street, New York City.

Victor C. Parker is no longer manager for the Waterloo Buick Co., Waterloo, Iowa. His plans for the future have not been announced.

(*Continued on page 8*)

PERSONAL NOTES OF THE MEMBERS

Concluded

F. H. Patten has severed his connection with Johns-Manville, Inc., for whom he was special representative at St. Louis. His plans for the future have not been announced.

R. A. Picard has been appointed general sales manager of the Metal Stamping Co., Long Island City, N. Y. He was formerly vice-president of A. J. Picard & Co., Inc., New York City.

William J. Quinn, formerly superintendent of service of the Murray-Van Sicklen Co., Chicago, has become associated with the J. W. Murray Mfg. Co., Detroit.

M. H. Roberts, chief engineer of the Franklin Railway Supply Co., New York City, has been appointed by Director H. Foster Bain of the Bureau of Mines, chairman of a board of engineers to study the production of helium in Texas.

N. G. Rost, who was formerly sales manager of the Duesenberg Motors Corporation, has been elected president of the newly formed Richelieu Motor Car Corporation, Asbury Park, N. J.

Ira S. Snead, general sales manager of Snead & Co., Jersey City, N. J., has been elected vice-president of the company, succeeding the late H. P. Macdonald.

Joseph T. Snow has been made sales engineer of the Beacon Oil Co., Boston. He was formerly chief engineer of the Texas Co., also of Boston.

C. M. Tichenor, formerly assistant general manager of the Pierce-Arrow Motor Car Co., Buffalo, N. Y., has become associated with the Rickenbacker Motor Co., Detroit.

F. W. Trabold has severed his connection with J. H. Williams & Co., Brooklyn, N. Y., where he held the offices of second vice-president and general sales manager. His plans for the future have not been announced.

James J. Tracy has been elected president of the Avenue Motor Co., Cleveland. He was formerly vice-president of the J. T. Tractor Co., also of Cleveland.

Wallace W. Tuttle, until recently vice-president and general manager of the Engineering Service Corporation, Detroit, has become associated with the Four Wheel Hydraulic Brake Corporation, Detroit.

John A. Vanneman has joined the Remy Electric Division of the General Motors Corporation, Anderson, Ind., as service engineer. He was previously engineer for Eisemann Magneto Corporation, Brooklyn, N. Y.

A. L. Vargha has accepted a position as designer with the Harrison Radiator Co., Lockport, N. Y. He formerly was connected with the Pittsburgh Model Engine Co., Pittsburgh, in the same capacity.

W. J. Walker, formerly engineer for the Menominee Truck Co., of Wisconsin, Clintonville, Wis., is now chief engineer for the Fulton-Flyer Truck Co., Houston, Tex., and is laying out the ¾-ton truck to be assembled by this company.

Harry F. White has severed his connections with the General Motors Export Co., New York City. No announcement has as yet been made on his plans for the future.

Louis B. Williams, formerly advertising manager for the Electric Auto-Lite Corporation, Toledo, has been made vice-president of the Osborn Sales Corporation, Kansas City, Mo.

Ernest J. Wissel has been made service director of the Fuller Automobile Co., Cincinnati. He was formerly connected with the Highland Auto Garage Co., Fort Thomas, Ky.

M. L. Yuster has been elected president of the Packard Coal Mining Co., Columbus, Ohio. He formerly held a similar office with the Ohio-Saxon Motor Car Co., also of Columbus.


THE automotive industry recognizes the value and the importance of SPECIALIZATION—of concentration upon the doing of one thing well. It appreciates, too, that the organizations that have done most for automotive progress, have been organizations that have devoted all their skill and energy to bringing individual parts to their highest degree of perfection.
It follows, therefore, that the foremost examples of modern hauling equipment necessarily are SPECIALIZED trucks—trucks that unite the highest attainments of many organizations of specialists working in harmony.
And since these SPECIALIZED trucks are equipped with units made by reputable specialists, it is only natural that dealers and distributors, in increasing numbers, should elect to sell them—should choose to link their own future with the sale of trucks that embody SPECIALIZED units of proven merit—such units, for instance, as the power-plant that bears on its crankcase the ranking insignia of motor-building SPECIALIZATION—the Continental Red Seal.
CONTINENTAL MOTORS CORPORATION
Offices: Detroit, U. S. A. Factories: Detroit and Muskegon
Largest Exclusive Motor Manufacturers in the World
NEW YORK—Booth C 60-61-62 Third Floor Grand Central Palace
CHICAGO—Booths 50 and 51, Gallery of the Coliseum
CONTINENTAL MOTORS
Powerful as the Nation
AMERICA'S STANDARD
Continental Motors

Differential Housing of Certified Malleable

Upholding Quality with Certified Malleables

Differential housings in trucks and motor cars are subjected to all the violent shocks and strains of motordom. Gigantic engine pull at one end, combined with road hammer at the other, demands material of high quality and integrity.

Housings of Certified Malleable meet these unusual demands. They have the stamina to stand the constant rack and terrific pounding of road service. Great tensile strength, high elastic limit and ductility are superior mechanical properties that insure low breakage, continuous service and long life to all vital parts made of Certified Malleable.

Materials of lower quality jeopardize safety, strength and endurance so necessary in trucks, motor cars and tractors. Certified Malleables are an important part of automotive construction. They uphold the quality, prolong the life, and in every way enhance the value of all products in which they are used.

Certificate holders listed here are manufacturers whose product for the quarter indicated has regularly met the requirements of the Association. In the judgment of the Association's Consulting Engineer, their plant practice is such as to produce uniform material of high character and integrity.

THE AMERICAN MALLEABLE CASTINGS ASSN.
The 1900 Euclid Building Cleveland, Ohio

Plants Awarded Certificates for the Quarter Ending Sept. 30th, 1921

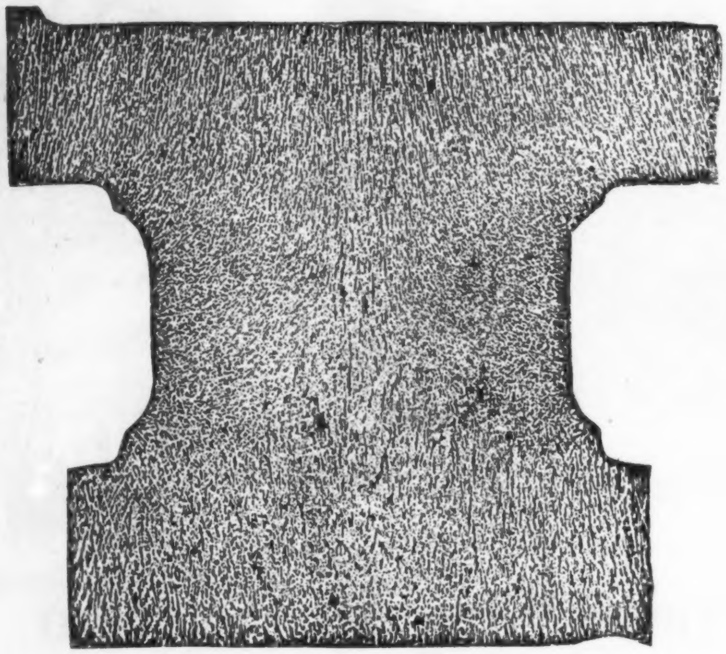
Albany Malleable Iron Co	Albany N. Y.
Albion Malleable Iron Co	Albion, Mich.
American Malleable Castings Co	Marion, O.
American Malleables Co	Lancaster, N. Y. and Owosso, Mich.
Badger Malleable & Mfg. Co	South Miwaukee, Wis.
Belle City Malleable Iron Co	Racine, Wis.
Chain Belt Co	Milwaukee, Wis.
Chicago Malleable Castings Co	West Pullman, Chicago, Ill.
Chisholm-Moore Mfg. Co., The	Cleveland, O.
Columbus Malleable Iron Co., The	Columbus, O.
Danville Malleable Iron Co	Danville, Ill.
Dayton Malleable Iron Co	Dayton, O. and Ironton, O.
Dearborn Iron & Power Co	Kansas City, Kan.
Decatur Malleable Iron Co	Decatur, Ill.
Devlin Mfg. Co., Thomas	Philadelphia, Pa.
Eastern Malleable Iron Co., The. Naugatuck, Malleable Iron Works, Naugatuck, Conn.; Bridgeport Malleable Iron Works, Bridgeport, Conn.; Troy Malleable Iron Works, Troy, N. Y.; Wilmington Malleable Iron Works, Wilmington, Del.; Vulcan Iron Works, New Britain, Conn.	
Erie Malleable Iron Co	Erie, Pa.
Federal Malleable Co	West Allis, Wis.
Fort Pitt Malleable Iron Co	Pittsburgh, Pa.
Frazer & Jones Co	Syracuse, N. Y.
General Malleable Co	Warren, O.
Globe Malleable Iron & Steel Co	Syracuse, N. Y.
Illinois Malleable Iron Co	Chicago, Ill.
Iowa Malleable Iron Co	Fairfield, Ia.
Kalamazoo Malleable Iron Co	Kalamazoo, Mich.
Laconia Car Co	Laconia, N. H.
Lancaster Foundry Co	Lancaster, Pa.
Link-Belt Co	Indianapolis, Ind.
Marion Malleable Iron Works	Marion, Ind.
Moline Malleable Iron Co	St. Charles, Ill.
National Malleable Castings Co., The	Cleveland, O.
Chicago Ill., Indianapolis, Ind., Toledo, O., E. St. Louis, Ill.	
Northern Malleable Iron Co	St. Paul Minn.
Northwestern Malleable Iron Co	Milwaukee Wis.
Peoria Malleable Castings Co	Peoria, Ill.
Pittsburgh Malleable Iron Co	Pittsburgh, Pa.
Pressed Steel Car Co	McKees Rocks, Pa. and Hegewisch, Ill.
Rhode Island Malleable Iron Works	Hillsgrove, R. I.
Rockford Malleable Iron Works	Rockford, Ill.
Ross-Meehan Foundries, The	Chattanooga, Tenn.
St. Louis Malleable Casting Co	St. Louis, Mo.
Saginaw Malleable Iron Co	Saginaw, Mich.
Standard Malleable Castings Co	Terre Haute, Ind.
Stowell Co., The	South Milwaukee, Wis.
Symington Co., T. H. The	Rochester, N. Y.
Temple Malleable Iron & Steel Co	Temple, Pa.
Terre Haute Malleable & Mfg. Co	Terre Haute, Ind.
Timken-Detroit Axle Co	Canton, O.
Trenton Malleable Iron Co., The	Trenton, N. J.
Union Malleable Iron Co., The	E. Moline, Ill.
United States Malleable Iron Co., The	Toledo, O.
Vermilion Malleable Iron Co	Hoopeston, Ill.
Wanner Malleable Iron Co	Hammond, Ind.
Wisconsin Malleable Iron Co	Milwaukee, Wis.
York Mfg. Co	York, Pa.
Zanesville Malleable Co	Zanesville, O.

POSITIVE PHYSICAL PROPERTIES
ACA CERTIFIED TRADE MARK

CERTIFIED-MALLEABLE CASTINGS

YOUR ENGINE'S BACK-BONE

By* DR. LESLIE AITCHISON



Macrosection of twisted journal of crankshaft.

Position of test piece	Ultimate Strength tons/sq. in.	Elongation per cent	Reduction of area per cent
Driving end of shaft (not twisted)	61.8	20.6	56.8
Twisted journals parallel to axis	57.0	3.3	6.0
Twisted journals parallel to twisted fibers	62.5	20.0	57.0
Twisted journals perpendicular to twisted fibers	51.6	0.	0.

"The crank to be considered shows the effects of twisting. The noticeable point, however, in regard to this twisting is that the macrostructure of the dissected journal shows that the twisting has been carried out over a very short length of the journal. Although twisting may be thought quite a harmless operation, yet in view of the profound effect that it has upon the mechanical properties of the steel in various directions (see table of tests), it is advisable to spread the operation of twisting over the greatest length of steel that is possible.

"It was not possible to take impact determinations, but probably these would be found to resemble the figures of the elongation per cent.

"In the specimen under examination, it will be seen that the twisting operation has been carried out on only about one-third of the journal, and therefore the amount of work which has been concentrated upon that part of the journal is very great, whereas the remainder of the journal has been left relatively untouched."

Canton TWISTLESS Crank Shaft Forgings possess a "snaky" grain, i. e., a grain which follows the contour of the shaft from end to end and whose continuity is NOT DESTROYED by any twisting.

We entirely eliminate the twisting operation, and you can incorporate this additional point of technical superiority in your product without increasing your cost.

We are at your service for the asking

CANTON DROP FORGING & MFG. COMPANY

CANTON, OHIO

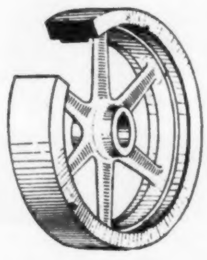
CANTON CRANK SHAFTS

*Extract from paper presented at Midland Institute, Birmingham, England

Proper Distribution of Weight

One of a Series of Talks on Motor Car Construction

By A. L. Putnam, M. S.A.E.



You need only one flywheel on a motor car — not five.

No automotive engineer today would think of putting five flywheels on a motor car—but that is just what the average car has, speaking literally.

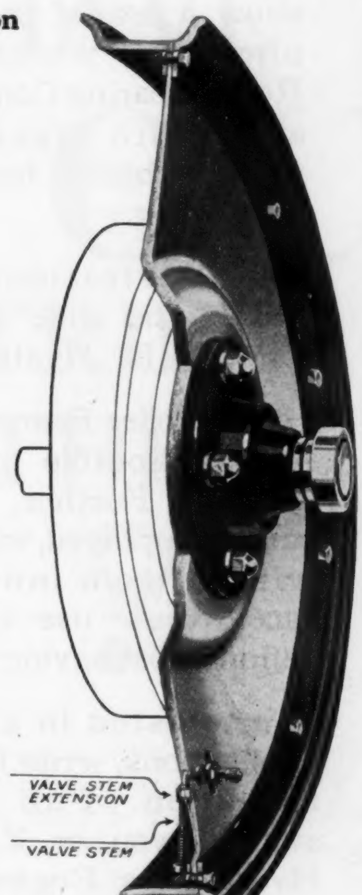
The greater proportion of weight in the average spoked wheel is at the rim. The result is a flywheel effect—a weakness which may not be apparent to the layman but which must be admitted by any engineer who investigates the subject.

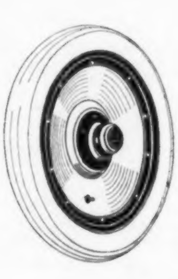
This construction means greater inertia to be overcome in starting—still more inertia in stopping. It means unnecessary strain on the motor and chassis.

The spoked type of wheel has been with us so long that too many take it for granted. Because it has been used for generations on wagons and other vehicles does not mean it is scientifically correct for motor cars.

In Disteel Wheels, the greater weight is at the hub, where it should be. This is made possible by the tapered disc. Yet, although Disteels are steel discs, they are the lightest wheels made, in relation to their strength and carrying capacity.

It will pay you to give some thought to this question of proper balance in wheels.





Disteels are properly balanced wheels.

Exclusive Manufacturers:

DETROIT PRESSED STEEL COMPANY

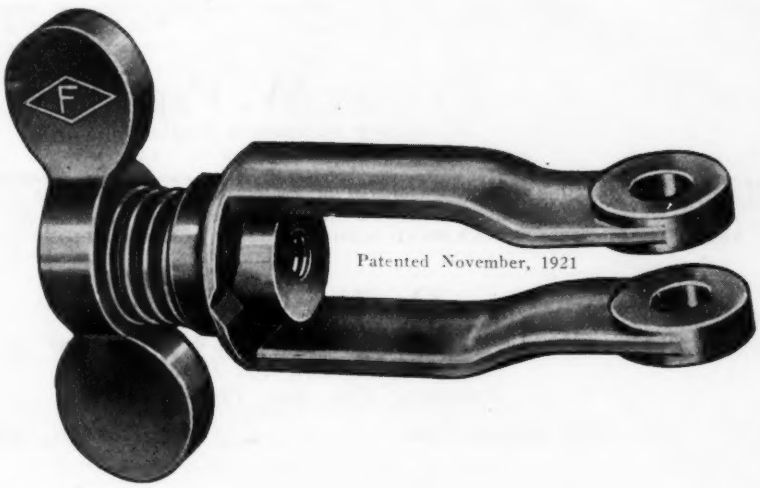
6660 Mount Elliott Avenue, Detroit

New York	Chicago	Boston	San Francisco
1846 Broadway	732 So. Michigan Ave.	925 Boylston Street	865 Post Street

DISTEEL WHEELS

GEMMER Brake Rod ADJUSTER

HAVE YOU TRIED THEM ?



Patented November, 1921

Used and endorsed by the following makers:

Acason
Allen
Ambassador
Available
Cole
Commonwealth
Day-Elder
Doble
Driggs
Elgin
Fageol
Fifth Avenue Coach
Fox
Fulton
Harmer-Knowles
H. C. S.
Larrabee-Deyo
Lexington
Milburn
Parenti
Parker
Premier
Ranier
Republic
R & V
Standard
Stutz
Titan
United
Ward La France
Yellow Cab

AUTOMOTIVE Engineers **must** keep up with the rapid developments which are being made daily in car design. The lack of a simple refinement may be the deciding factor in the purchaser's mind which shifts the sale to his competitor. Owners appreciate the little things which make car adjustment a simple detail instead of a major operation.

GEMMER BRAKE ROD ADJUSTERS appeal to the car owner. He does not need a kit of tools to take up brake rods which rattle. He does not need to remove clevis pins, obstinate cotters or check nuts to take up wear. And when the adjustment is made the clevis is automatically locked.

WE want to give you a set for trial on your experimental car. When you have replaced the old yoke and check nut with this simple device, you will understand why they appeal to the car owner.

They Cost No More Than Your Present Turnbuckle Assembly

The Gemmer Adjuster eliminates parts and speeds up assembly on the production line. It is forged; accurately finished and interchangeable with S. A. E. Standard yoke ends and pins.

M. J. Ford Manufacturing Co., 307-11 Newark St., Hoboken, N. J.

Also manufacturers, Standard Drop Forge Brake Levers, machined and in the blank; plain and adjustable yoke ends and brake rod assemblies.

■ MEMBERS' PROFESSIONAL CARDS ■

AERONAUTICAL ENGINEERS
A. & D. R. Black
CONSULTING—DESIGNING—SUPERVISING—ENGINEERS
AIRCRAFT — LANDING FIELDS — EQUIPMENT

—— MAIN OFFICE —— 22 EAST 17TH STREET NEW YORK, N. Y.
—— BRANCH OFFICE —— EVENING STAR BUILDING WASHINGTON, D. C.

S. A. E., *New York* A. S. M. E., *New York.* I. A. E., *London*
Cornelius T. Myers, M. E.
CONSULTING ENGINEER
REPORTS—DESIGN—TESTS—DEVELOPMENT
Magazine Oiling Systems for Springs, Shackles and Universal Joints
RAHWAY NATIONAL BANK BLDG. RAHWAY, N. J.

Ethelbert Favary
(Author of "Motor Vehicle Engineering" for Designers)
CONSULTING DEVELOPMENT DESIGNING RESEARCH
Engines and Chassis Redesigned for Quantity Production.
4 cycle, 2 cycle and air-cooled engines. Tests of automotive machines, devices and strength of materials. Most modern and complete **Testing Laboratory.**
Cooper Union, 3d Ave. and 6th St., New York

Victor W. Pagé
Consulting Automotive Engineer
Automobiles Tractors Aircraft
Preparation of engineering opinions, reports, also catalogs, prospectus, bulletins or publicity material in non-technical language solicited.
309 Lafayette Street, New York City
c/o RAYMOND ENGINEERING CORPORATION

James Guthrie
Engineers Building
CLEVELAND
Consulting Mechanical Engineer
Motor Vehicle Design and Engineering Plant Organization
Industrial Reports and Analysis
MEMBER: A.S.M.E. S.A.E.

C. T. Schaefer
(Author of Motor Truck Design & Construction)
Consulting, Design and Development
Passenger Car and Truck Design
2641 Russell Ave. ST. LOUIS, MO.

Bert M. Kent, M. E.
Patent Lawyer
PATENT SOLICITING—INVESTIGATIONS—REPORTS
Specialist in Motor Vehicle Patent Work
CLEVELAND DISCOUNT BUILDING CLEVELAND

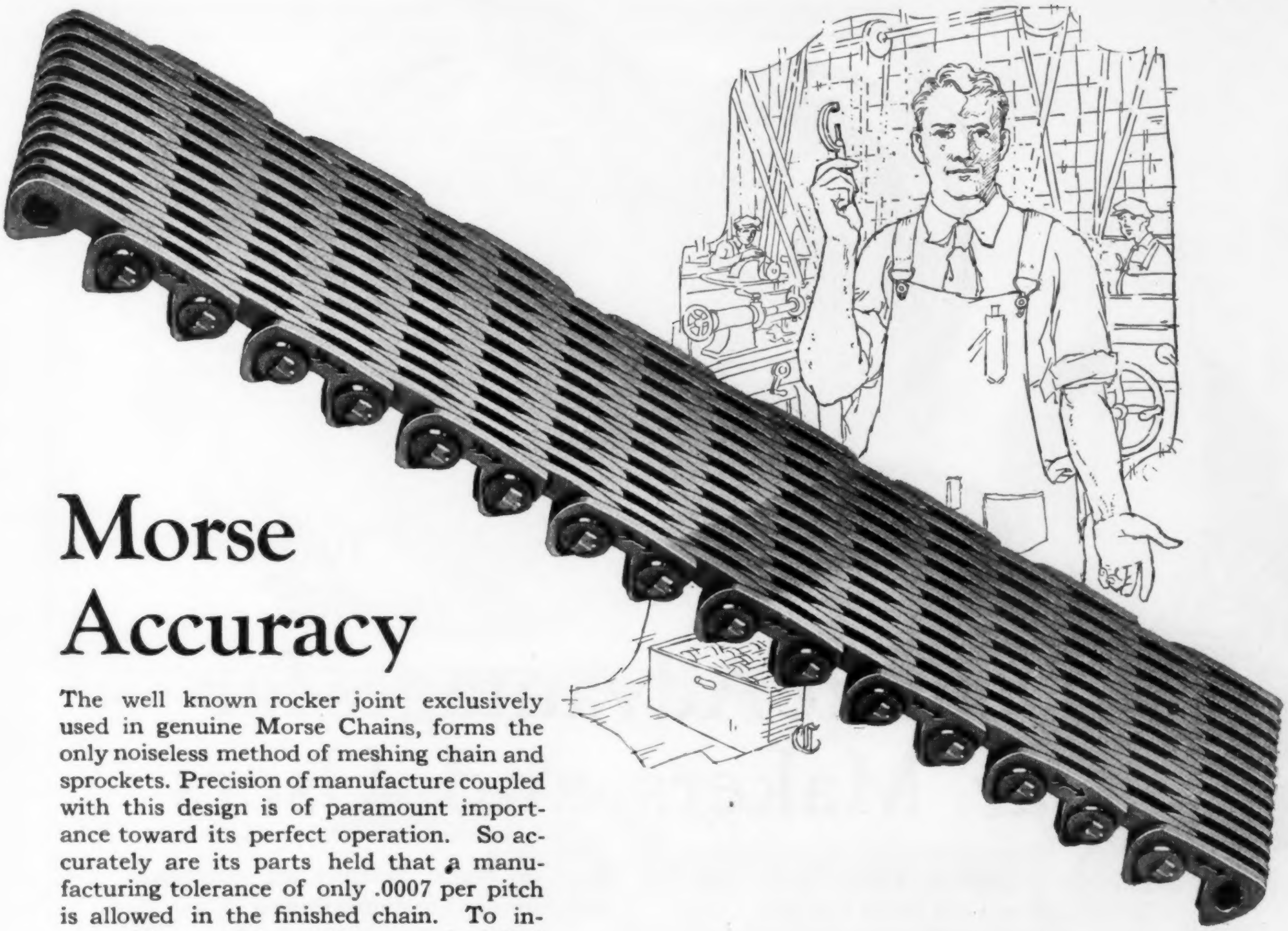
S. A. E. A. H. T. A. Rotary Int.
O. E. Szekely
N. G. E. A. N. I. V. A.
MOLINE, ILLINOIS
Mechanical and Automotive Engineer.
Engineering and Laboratory Departments. Complete Experimental Equipment. Testing Machines. Universal Machine Shop and Pattern Shop for Single Piece Reproduction of Our Designs.

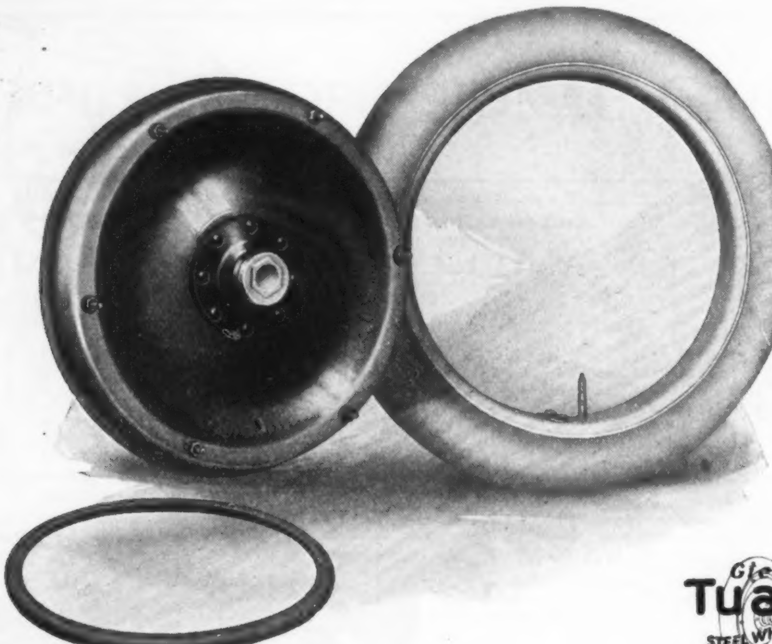
Benjamin Liebowitz, PhD.
Seismographic Measurement of Performance of Tires, Shock Absorbers, etc. Special Seismographic apparatus developed for measurement of engine vibrations and all other types.
c/o MONIDYNE VEHICLE SUSPENSION CO.
949 Broadway New York, N. Y.

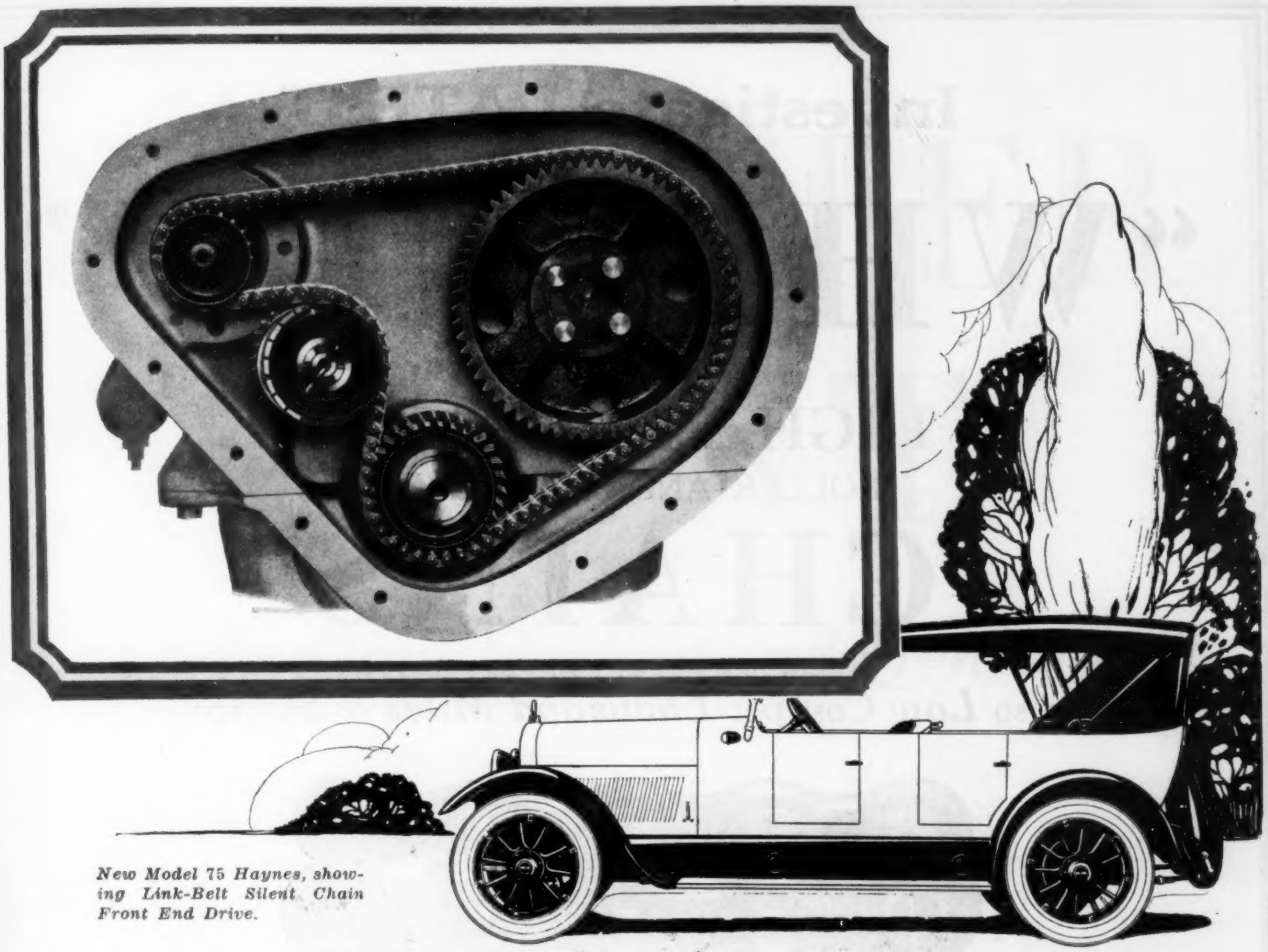
Tel. Murray Hill 8165
Adrian Van Muffling
and
Harry J. Marx
Consulting Aeronautical and Automotive Engineers
299 Madison Ave., cor. 41st St., NEW YORK CITY

Chas. M. Manly, A. S. M. E. S. A. E.
Manly and Veal
C. B. Veal, A. S. M. E. S. A. E.
(Consulting Engineers)
mechanical—automotive—industrial
Coordination of engineering and manufacturing requirements in the design, production and operation of automotive power plants and vehicles.
Design, Development, Specifications, Organization, Inspection, Investigation, Tests and Reports
250 West 54th Street, New York City.

Information regarding the space available on this page can be secured by addressing the Society.







New Model 75 Haynes, showing Link-Belt Silent Chain Front End Drive.

The Link-Belt Silent Chain Front End Drive on the new Haynes models (see illustration) operates the cam and auxiliary shafts. The chain is of the standard Link-Belt back type (with teeth on both front and back).

The Link-Belt automatic idler, with which the drive is equipped, keeps just the right operating tension on the chain at all times. There is no chance of its becoming loose. The idler acts as a dampener on vibration, maintaining absolute silence in the drive.

The contact of the chain on the crank shaft wheel is more than doubled, preventing the possibility of jumping a tooth in a hasty stop, or under back fire.

The back type chain engages the idler with a positive contact that prevents slippage.

These are advantages that engineers have been seeking for a long time, and this design marks a distinct advance in the art of front end driving.

We shall be glad to send you more detailed information.

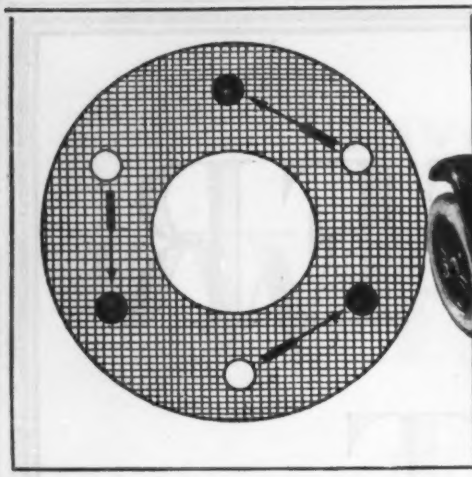
LINK-BELT COMPANY

828

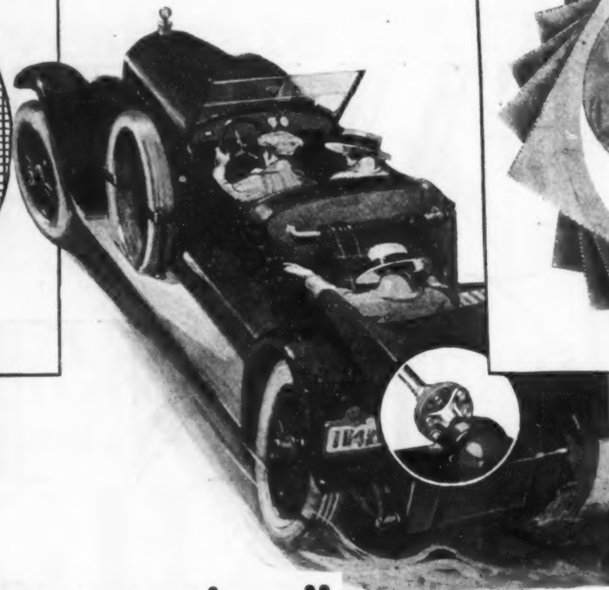
West Michigan St. and Holmes Ave. INDIANAPOLIS, IND.

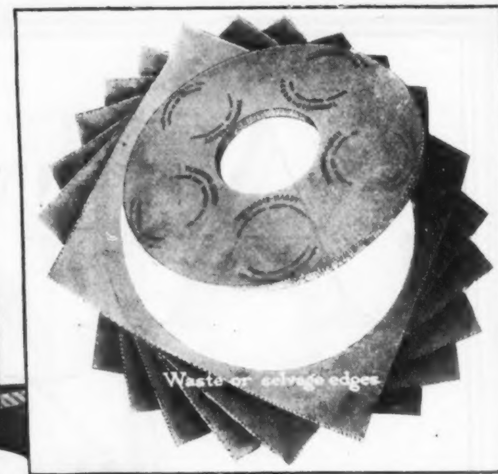
LINK-BELT

Silent Chain Front End Drives



Ordinary Disc





Thermoid-Hardy Fanwise Construction

"Fanwise construction" in the Thermoid-Hardy Universal

The graphic story of the disc type of universal joint

SEVENTY-FIVE manufacturers have adopted the Thermoid-Hardy Universal Joint as standard equipment on passenger cars, trucks and tractors. As the original disc universal, the Thermoid-Hardy not only has replaced metal joints, but has remained the leader in its field.

The two diagrams above tell the story. At the left is an ordinary disc, its layers of fabric laid parallel. The three black holes are the driving bolts—the three white ones the driven. Notice that the left hand driving bolt is the only one that can pull in the direction of the strands of cotton. The other two must pull on a bias. This stretches the whole disc out of true, causing vibration and whipping of the entire shaft.

In contrast, examine the Thermoid-Hardy patented fanwise construction. Notice how the disc is built up with the strands of each layer of fabric running in a different direction. Each sector is of uniform strength and elasticity. Every stress is balanced

—the torsional stresses between the bolt holes;
—the centrifugal stresses from the center outward;
—the lateral stresses from the forward and back motion of the shaft.

You should have this book—sent free to any engineer

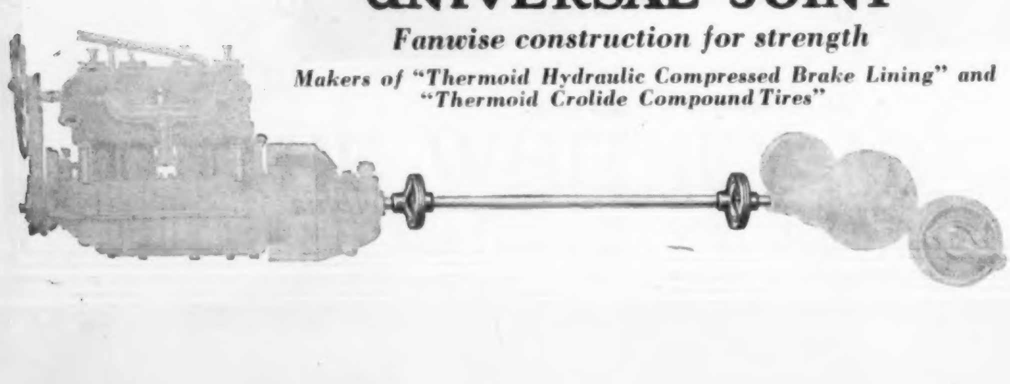
We have prepared a book, "Universal Joints—Their Use and Misuse," that treats the whole subject from all its angles—the mechanical principles involved, construction, lubrication, processes of manufacture, tests for strength, and records of performance. Send for a copy today.

THERMOID RUBBER COMPANY
Sole American Manufacturers
Factory and Main Offices: Trenton, N. J.
New York Chicago, San Francisco, Detroit
Cleveland, Atlanta, Boston, London, Paris, Turin

THERMOID-HARDY UNIVERSAL JOINT

Fanwise construction for strength

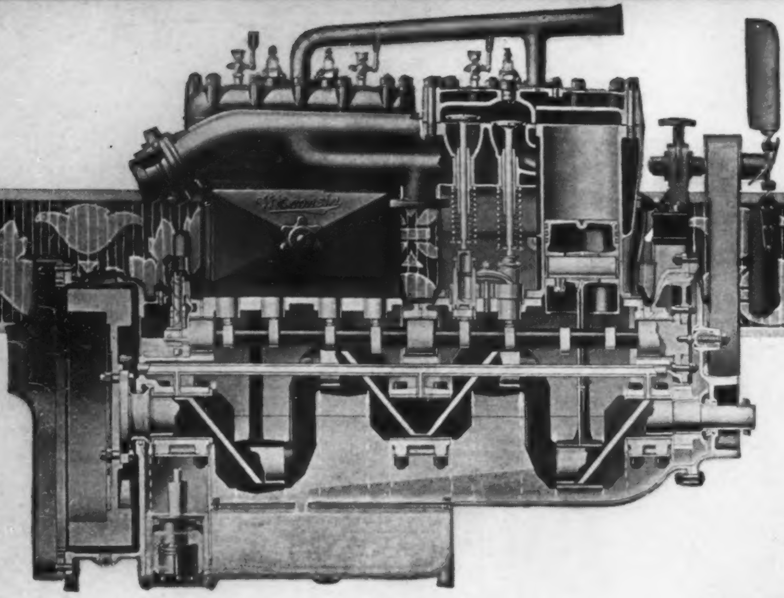
Makers of "Thermoid Hydraulic Compressed Brake Lining" and "Thermoid Crolide Compound Tires"

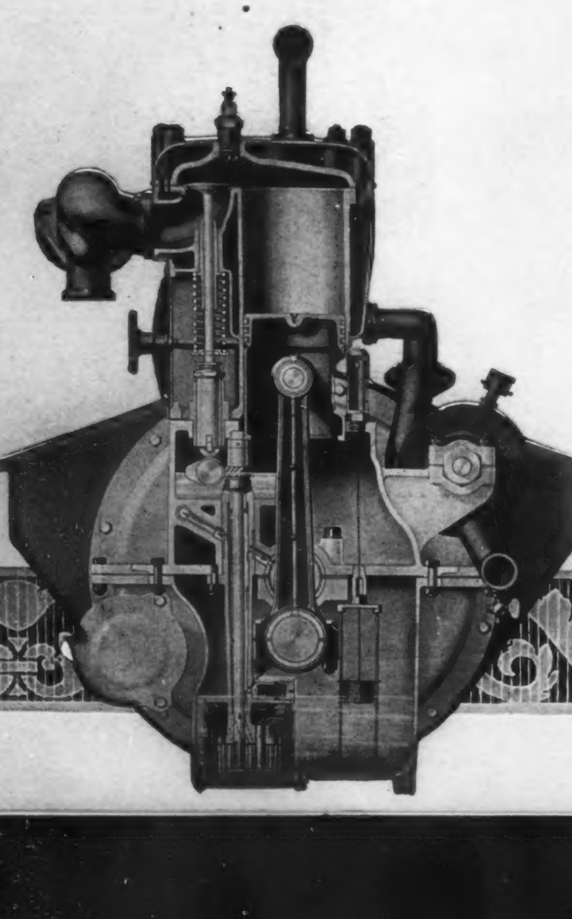


List of Users

American British Mfg. Co.
Allis-Chalmers Mfg. Co.
Anderson Motor Co.
The Autocar Co.
Available Truck Co.
Barley Motor Car Co. (Roamer)
Crow-Elkhart Motor Corp.
Jas. Cunningham Son & Co.
Dart Truck & Tractor Corp.
The Dauch Mfg. Co.
Diamond T Motor Car Co.
Doane Motor Truck Co.
Elgin Motor Car Corp.
Elgin Street Sweeper Co.
Fageol Motors Co.
Fifth Ave. Coach Co.
H. H. Franklin Mfg. Co.
Garford Motor Truck Co.
Gramm-Bernstein Motor Truck Co.
Handley Knight
Hawkeye Truck Co.
Hebb Motors Co.
Hendrickson Motor Truck Co.
Highway Motors Co.
Holt Mfg. Co.
Indiana Truck Co.
International Harvester Co. of America, Inc.
International Motor Co.
Jackson Motors Corp.
Kentucky Wagon Mfg. Co., Inc.
Kenworthy Motors Corp.
King Motor Car Co.
King Zeitler Co.
Lakewood Eng. Co.
Larrabee-Deyo Motor Truck Co.
Lexington Motor Co.
Locomobile Co.
Menominee Motor Truck Co.
Mercer Motors Co.
Moreland Motor Truck Co.
McFarlan Motor Co.
Nelson & LeMoon
E. A. Nelson Automobile Co.
Nelson Motor Truck Co.
D. A. Newcomer Co.
O'Connell Motor Truck Co.
Oliver Tractor Co.
Oneida Motor Truck Co.
Packard Motor Car Co.
Parker Motor Truck Co.
Reliance Motor Truck Co.
Reynolds Motor Truck Co.
Root & Van Dervoort Eng. Co.
Sanford Motor Truck Co.
Southwark Fdy. & Mach. Co.
Sprague Electric Co.
Stoughton Wagon Co.
Studebaker Corp.
Stutes Mar Tractor Co.
Templar Motors Co.
Tioga Steel & Iron Co.
Towmotor Co.
Traffic Motor Truck Corp.
Transport Truck Co.
Twin City Four Wheel Drive Co., Inc.
United Motors Co.
Walter Motor Truck Co.
Ward La France Truck Corp., Inc.
Watson Products Corp.
Geo. D. Whitcomb Co.
Wichita Motors Co.
H. E. Wilcox Motor Co.
J. C. Wilson Co.
Willys-Overland, Inc.
Zeitler & Lamson Truck & Tractor Co.


SALISBURY
Axles for Passenger Cars
Sheldon
Axles for Motor Trucks
Sheldon
Springs for Motor Cars and Trucks
Parish
Heat Treated Frame
Spicer
Propeller Shaft





Positions & Men Available

The following announcements are published for the benefit of members of the Society and the convenience of companies in need of men. No charge whatever is made for this service. In the case of items prefixed by an asterisk further information is withheld at the request of the company or individual making the insertion, but written communications bearing the number of such items will be forwarded by the S. A. E. Office. In other cases further information will be supplied by the Office of the Society. Applications for positions from non-members must be endorsed by a member of the Society.

0154 GENERAL MANAGER for automobile body plant desires position. Experience includes 20 years as mechanic, engineer and superintendent and factory, business and sales management. Competent to produce open or closed work from raw material to the finished product, including paint, trim and final assembly. Available at once.

0193 MECHANICAL ENGINEER with industrial and executive experience who is familiar with modern methods of manufacturing, production and organization wishes responsible work with a progressive organization. Eastern States or foreign service preferred. Age, 31; married.

0250 ENGINEER Keen, energetic, experienced and reliable man with 14 years' practical experience in automobile and aircraft lines covering various executive positions in designing, development and experimental work desires to make a permanent connection with a reliable organization where ability, energy and initiative are wanted. Has been associated with the leading engineers and largest manufacturers in the country. Can serve as a commercial representative, experimental manager, chief engineer or assistant. Will go anywhere. Age, 31; married. Excellent references can be furnished.

0255 EXECUTIVE AND DESIGNING ENGINEER experienced in track-laying tractor and transmission design, factory planning, power transmission and conveying machinery desires responsible position with truck, tractor, or parts manufacturer. Age, 37; unmarried. Available at once.

0256 PRACTICAL ENGINEER with 12 years' experience in experimental testing and laboratory work and 8 years in service repairs. Expert on internal-combustion engines. Available at once. No preference as to location. Age, 36; married.

0257 AUTOMOTIVE ENGINEER with 9 years' experience in the design and production of automobiles, trucks, tractors and airplane engines, specializing in internal-combustion engine design and construction. Capable of organizing and supervising engineering department. Good references. Location immaterial. Age, 29; married.

0258 YOUNG MAN with five years' experience in the design, layout and construction of automotive parts, crude oil engines, motor cultivators and garden tractors, wishes to change position. Available now. Age, 24; single. Location, immaterial.

0259 ENGINEER Nine years' experience in electrical, testing and finished inspection and experimental laboratory departments. For past year in complete charge of research laboratory and garage.

0260 GRADUATE MECHANICAL ENGINEER with 13 years' experience in tool engineering and factory management, desires a position as chief tool designer or assistant factory manager. Location, Detroit preferred, but not essential.

(*Continued on page 46*)

MEN AVAILABLE
Continued

0261 ENGINEER experienced in production, inspection and research, desires a position in Michigan, Indiana or Wisconsin, but would consider other location. Available after one month's notice. Married; age, 34.

0262 ENGINEER will consider position as department foreman, superintendent of small plant or traveling salesman. Has had 16 years' experience in nearly every phase of the automobile industry and for past 9 years has been manager of prominent manufacturing company.

0264 ENGINEER Technical graduate, lately in Government service as automotive engineer in Ordnance Department; shop organizer, production manager and general superintendent of largest Government shop in the East, wishes to make connection with reliable firm, representing them in Western territory in either manufacture or sales. Best of references furnished. California headquarters preferred. Age 35.

0266 TECHNICAL GRADUATE desires to secure a position as plant or automotive engineer. Twelve years' experience. At present chief engineer of well-known company building high-grade automobiles.

0269 ENGINEER Ten years' experience in the design and manufacture of automotive parts, transmissions a specialty. Married; age, 28.

0271 ENGINEER and designer of trucks, tractors and passenger cars desires a position. Age, 30; unmarried. Available at once.

0272 PURCHASING AGENT who is familiar with all phases of the automotive industry, and is also a practical engineer, desires position. Unmarried; age, 30. Available at once.

0275 YOUNG ENGINEER Experienced in aircraft design, production, construction, development, inspection and experimental work. Technical graduate. Age, 26; unmarried. Location, immaterial. Available now.

0276 AUTOMOTIVE ENGINEER University graduate with four years' experience in the layout and design of leading automobile truck and tractor, who has done considerable research and design work on gears, wishes to connect with a progressive company. Has had some sales experience and can furnish excellent references.

0278 CHIEF INSPECTOR who has had 12 years' experience on passenger cars and trucks. Has been associated with large automobile company for past three years exercising complete supervision of the entire plant including both the incoming material and the finished product.

0279 YOUNG MARRIED MAN desires permanent position in either the engineering or the service department with a company building passenger cars in or near Chicago, Cleveland or on the Pacific coast. Available on 10 days' notice.

0280 CHIEF ENGINEER or factory manager with 15 years' experience is available at once for permanent or temporary position. Has an established reputation and professional standing in the automotive industry.

0281 HIGH-GRADE EXECUTIVE with 15 years' experience in management and sales engineering in the truck, tractor and engine organizations is desirous of connecting with a manufacturer where opportunities are big. An expert in organizing, planning and management. Age, 35; married. Available at once. No preference as to location.

0283 AUTOMOTIVE ENGINEER experienced in development and design desires to make a permanent connection with a motor-truck or passenger-car builder. Age, 34; married. Available on reasonable notice. East preferred.

0285 ENGINEER who has developed a successful steam car built with 90 per cent of standard automobile parts is available for position. Has now finished the design and detail drawings, his own property, and wishes to meet party interested in building a finished car on an equitable basis.

(*Continued on page* 48)

See announcement at the head of the "Positions and Men Available" column, page 44.

MEN AVAILABLE
Continued

0286 Mechanical and Electrical Engineer Technical graduate with 12 years' experience, a specialist on oil engines and capable of taking charge of the design and construction of high-speed oil engines. truck axles, jigs and tools, desires a position with a progressive company. Best of references. Age, 35; married.

0287 Electrical Engineer Graduate in electrical engineering with 12 years' experience in research and development work on motor control for general motor applications, including traction, electric automobiles and trucks. Age, 33; married.

0288 Mechanical Engineer competent to act as works or production manager, chief engineer or assistant to executive, desires a position where initiative and inventive ability along manufacturing lines are considered. Experience includes 12 years as machinist, designer, chief draftsman and efficiency and production engineer. Wide experience in designing special machinery, tools, jigs, fixtures, gages and dies. Has been engaged for the past three years in airplane design and construction and is familiar with the use of duralumin. Capable of handling men and supervising responsible work. Can speak French and Italian. Will go anywhere in the United States and will consider South American or European work. Best of references. Available on short notice.

0289 Young Engineer with two years' experience in experimental and shop work desires a position in the engineering department of a progressive company. College graduate. Age, 26. Willing to go anywhere.

0290 Mechanical Engineer desires position. Has had seven years' experience as metallurgist and testing engineer for plants manufacturing automotive products. Experience also includes selling and public utility work. Married; age, 30. Available at once. Middle Atlantic States preferred but not essential.

0291 Mechanical Draftsman and Tool Designer with eight years' experience on automobile transmissions, clutches, universal-joints, tractors and the tools, jigs and fixtures required in their production, desires a position with a progressive automotive company in these lines or to take charge of assembling or testing. Location, Detroit or Middle West. Age, 28; married. Available at once.

0292 Mechanical Engineer Ten years' experience in design, experimental work and production. Technical graduate. Has held the positions of assistant, chief and consulting engineer. Available immediately. Age, 34; married.

0293 Automotive Sales Engineer is open for engagement. Has had both foreign and domestic experience.

0296 Automotive Engineer Technical graduate with 12 years' experience in the development and construction of high-price passenger cars and trucks and for the last few years chief experimental engineer with one of the largest companies in the country. Best of references.

0297 Metallurgist with technical education, executive ability and over six years' experience in general laboratory and heat-treating practice, desires to make connection with a progressive manufacturer. At present holds a responsible position with a prominent organization. Will consider any location, but Pacific coast preferred. Age, 29.

0301 Sales Engineer College graduate with eight years' experience as a sales engineer and four in the automotive trade desires a position with a reliable accessory manufacturer. Age, 32; married. Location, immaterial. Available at once.

0302 Designer Experienced in the design and inspection on uptodate metal or wood airplanes. Has held an executive position on airplane design and construction. Possesses a broad knowledge of all high-speed motor vehicles. Best of references and record of personal achievements furnished. Prefer Middle West territory, but would consider any other locality. Married; age, 34.

(*Continued on page* 50)

See announcement at the head of the "Positions and Men Available" column, page 44.

MEN AVAILABLE

Continued

0303 DESIGNER with several years' experience wishes to connect with manufacturer of cars or bodies or parts as chief draftsman. Experienced in handling men and correspondence and installing systems. Age, 27; unmarried. Available immediately.

0304 MECHANICAL ENGINEER Technical graduate with seven years' broad engineering and executive experience in the automotive industries covering rubber products, aeronautics, motor cars and trucks. Will go anywhere, but would prefer Middle West.

0305 AUTOMOTIVE ENGINEER with eight years' experience in automobile, truck, tractor and power farming machinery; also tool design and drafting who has held the positions of chief draftsman, factory superintendent and assistant chief engineer desires a position in the engineering or the service department of an automobile, truck or tractor firm. Middle Western location preferred, but not essential. Age, 24; unmarried.

0306 MECHANICAL AND ELECTRICAL ENGINEER Technical graduate and factory executive with long and varied experience in the design and manufacture of high-class accurate machinery wishes to connect with a firm where he can prove what he is able to do. Is especially well qualified in special tooling and manufacturing methods and has handled practically every department in manufacturing plant. Available now. Married; age, 47. Location immaterial.

0307 ENGINEERING MANAGER OR CHIEF ENGINEER Position wanted by engineer of technical and business experience who has been connected with one of the financially successful motor-car companies as chief engineer for 10 years and has specialized in the complete cooperation between manufacturing and finance departments to secure commercial success.

0308 PRODUCTION AND INSPECTION EXECUTIVE Man with practical experience of twenty years in the automobile and truck business wishes a position with a reliable company where merit is recognized with promotion. Age, 47; married. Available ten days after notice. Location immaterial.

0309 AUTOMOTIVE AND ELECTRICAL INSTRUCTOR Practical man with ten years' mechanical experience, including two years as senior instructor. Married; age, 27. Available at once.

0310 AUTOMOTIVE ENGINEER 33 years of age with an excellent record in the design, testing and development of particularly difficult problems of special improvements and accessories for the automobile powerplant and chassis desires to connect with firm requiring a specialized development engineer who has ingenuity, progressive ideas and a practical knowledge of this line of work. Available, Jan. 1. Single. Prefers New York City but would consider other location.

0311 ENGINEER Long experience in production, sales work, truck manufacturing and distribution. Has held positions of general manager and executive and has spent some time abroad with a tractor to be used in reclamation work. Age, 49; married. New York City preferred but not essential. Available immediately.

0312 YOUNG MECHANICAL ENGINEER desires a position in development or production work. Nine years' similar experience with organizations building airplane and stationary engines, airplanes and small tractors. Capable worker accustomed to responsibility. First-class references. Available now. Single; age, 27. Boston preferred but not essential.

0313 ENGINEER AND EXECUTIVE who has spent seventeen years with prominent automobile manufacturers on designs and production and in executive capacities seeks new connections. Has designed and produced complete automobiles and trucks, including engines, transmissions and axles, and recently completed models of new passenger car possessing many distinctive features and of unusually light-weight construction. Several years' executive responsibility. Is thoroughly conversant with latest production methods. If desired can furnish a competent organization. Married; age, 37. Location immaterial.

(*Continued on page* 52)

See announcement at the head of the "Positions and Men Available" column, **page 44.**

POSITIONS & MEN AVAILABLE
Continued

0314 TECHNICAL GRADUATE desires a position as metallurgist or superintendent of heat-treating. Six years' extensive experience in the chemical and physical testing and heat-treatment of carbon and alloy-steels. Best of references. Age, 31; married. Available after two weeks' notice. New York or New Jersey preferred but not essential.

0320 EXECUTIVE Successful organizer as manager, general superintendent and engineer with 14 years' experience in handling men mostly in the construction of marine and automobile engines. Has had practical as well as technical training in the shop and the foundry. Age, 39; married. Prefer Cleveland or vicinity. Available at once.

0321 MECHANICAL ENGINEER Experience includes 16 years as chief draftsman and designer, also broad experience in the designing of special machinery, tools and dies. Age, 41; married. Available on one week's notice. Location immaterial.

0325 COMMERCIAL BODY ENGINEER AND DESIGNER Man with a good record who has experience in modern commercial body design including cabs and windshields and standard and special platform and stake, express and panel bodies and is capable of managing a body shop wishes to connect with a firm where there is an opportunity for advancement. Has made a particular study of bus bodies. Available on two months' notice. Age, 28; married. Location immaterial.

0326 ASSISTANT FACTORY MANAGER Technical graduate and competent executive with 12 years' practical experience as assistant production manager, superintendent, machinist and tool maker. Is familiar with factory organization and production methods for quality and quantity production and has an appreciation of costs in general and especially factory costs in various industries through work as a consulting engineer. Detroit preferred.

0327 AUTOMOTIVE ENGINEER with sixteen years' experience who has built a truck engine in a way to economize upkeep is available for position where he can be of service along this line.

0328 ENGINEER Fifteen years' automobile engineering, designing and supervision experience and for the past five years assistant engineer of prominent automobile company. Available immediately.

0329 ENGINEER with an exceptional practical mechanical experience including experimental improvement and general development work and production, purchases and design. Is capable of taking the entire charge of the engineering department of a small or medium-sized passenger-car, truck or engine factory, preferably the last. Possesses a thorough knowledge, both theoretical and practical, of internal-combustion engineering. Has held the position of chief engineer and has built, developed and exploited a semi-sleeve valve engine. Age, 37; married.

0331 EXFCUTIVE MECHANICAL ENGINEER Man who has specialized in automobile and tractor engine transmission and rear-axle design and also automatic production and general machine design. Experienced in purchasing and general executive requirements of large and small organizations. Age, 35; married. Available now.

POSITIONS

111 INSTRUCTOR Man with a thorough knowledge of automotive electrical equipment. Must be young and possess ability to handle young men. An ex-service man would fit in well if he had the necessary qualifications

116 SALESMEN who have initiative, strong personality and who have been in direct contact with the buying public are desired to sell passenger cars on a commission basis.

(*Continued on page* 54)

See announcement at the head of the "Positions and Men Available" column, page 44.

Interstate Alloy Steels

ARTIST VERNON HOWE BAILEY, when he sketched the picture below, caught the spirit and the tense action of the hundreds of workers in the Interstate Billet Chipping department, at our South Chicago Works. But the readers of this publication will see more in this picture than even that world-famous artist saw.

Your practical mind will grasp, as we do, the importance of removing the smallest defect in every alloy steel Billet before it is heated for rolling into bars. You are familiar with the behavior of alloy steel (especially the nickel group) in the rough-rolling process which reduces ingots to billets, and have seen the surface creases and seams in the cooled billets. And you can imagine the cost to us of pickling, inspecting and chipping every individual billet.

Our care in this department and our slow method of rolling the reheated billets—many passes, with a small reduction at each pass—coupled with our advanced pack-annealing practice, insures finished bars or spring steel of a uniformly dependable high quality.

We supply all S A E specifications as well as many special analyses of our own; and we are skilled and patient in working out customers' analyses as well.

Interstate Iron and Steel Co.
104 South Michigan Avenue, Chicago
Branch Offices—New York, Cleveland, Detroit, Milwaukee, St. Paul, St. Louis, Kansas City, San Francisco

POSITIONS AVAILABLE
Continued

127 SALESMAN who is in close touch with automotive engineers is desired, to introduce to the industry several laboratory devices including a high-speed balanced diaphragm type indicator.

135 RESEARCH ENGINEER to take charge of lubrication department of Government laboratory at Washington.

140 SALES ENGINEER Manufacturer of electrical equipment requires traveling sales engineer to sell product to manufacturers of high-grade automobiles and gasoline engines. Unusual opportunity for first-class man having broad selling experience.

146 ENGINEER who is experienced in ignition work. Drafting experience essential. Good opportunity for advancement. Location Pennsylvania.

151 CITY SALESMAN to call upon repair shops, garages and large users of motor trucks and sell them magnetos. Location, New York City.

160 SALES MANAGER who is familiar with the sale of gears and gear cutting machinery. Location, Indiana.

164 SALES ENGINEER ON CARBURETERS Preferably a man with technical experience and acquaintance among the large automobile manufacturers. Must be of highest character and have initiative to work up a new proposition. Returns will be commensurate with results achieved. Location, Wisconsin.

174 RESEARCH ENGINEER, for work on starting and lighting. Man with experience along this line and who can take charge of the work immediately. Location, Boston.

175 SALES ENGINEERS Location, Ohio.

179 TRANSPORTATION SALES ENGINEER to represent Southern company in New England and New York on commission basis, selling trailers and motor-truck equipment.

181 SALESMAN with some experience in ignition, or at least in some part of automobile work. A high-grade man who can get business for the company is wanted. Location, Pennsylvania.

182 SALES MANAGER for a large motor-truck company located in Ohio. Must be a man of wide experience and capable of handling a large number of men in the field.

*183 DESIGNER OR DRAFTSMAN who is capable of handling ball-bearing layouts and applications and making recommendations as to sizes. Must have had a considerable amount of actual experience in this work. Excellent opportunity for high-grade man. Location, Pennsylvania.

188 SALESMAN Man with successful experience in selling automobiles at wholesale is wanted by Philadelphia firm.

190 SALESMAN for passenger cars. Location, New York City.

192 DRAFTSMAN Temporary position with motor-vehicle company. Location, New York State.

193 PRODUCTION MAN Wanted an experienced and practical man. He must have the highest credentials and at least 10 years' experience building medium-priced cars. A permanent position for the right person. Correspondence confidential. Location, Florida.

*194 SALES MANAGER is wanted by a well-known automobile organization selling a medium priced individual type of car. A man capable of enlarging and developing the present dis-

(*Concluded on page* 56)

See announcement at the head of the "Positions and Men Available" column, page 44.

POSITIONS AVAILABLE
Concluded

tributors' organization, and who is thoroughly experienced in the selling end of the automotive industry is desired; preferably one who is now assistant sales manager, and who would be ready to step into the position of sales manager whenever the opportunity is offered. Location, Delaware.

*195 SECRETARY capable of handling own stenographic work is wanted by a prominent truck building company. Some mechanical knowledge and good personality essential. Good salary prospects for the right man. University graduate preferred. Location, New York City.

*196 MAN WITH IDEAS OR DESIGNS, patented or otherwise, of a light cheap horn is desired by a large manufacturing company intending to enter the automobile horn field.

198 LAMP SALESMAN. Must be thoroughly familiar with automobile lamps, acquainted with the trade and qualified as to mechanical knowledge. A previous successful record in this line is essential. Give experience in detail and personal description. Location, Boston.

200 ENGINEER qualified to furnish a complete design of motorboat engines is wanted by Government. Preferably a man to develop these designs in the department so as to be able to have the advice and criticism of officers responsible for the design, but if this is not possible, designs could be prepared outside and submitted for criticism. Location, Washington.

201 ENGINEER to take full charge of an office and warehouse, carrying a well assorted stock of high-grade steel products such as tool, drill and high-speed steels, etc., is wanted for foreign service by a prominent steel company. Applicant must be an experienced steel salesman, practical, absolutely trustworthy, well recommended, thoroughly familiar with modern methods of heat-treating and qualified to act as a demonstrator. Man acquainted with the conditions peculiar to the Eastern markets preferred.

202 MAN thoroughly competent to handle the production design of automotive lamps. Must have had a number of years' actual experience in designing lamps for manufacture on a production basis. Location, Boston.

203 BODY DRAFTSMEN wanted by one of the established builders. Should be capable of making full-size body drafts and understand projection and all body framework and metal parts. Location, Detroit.

205 PACKAGE DELIVERY COMPANY commencing operations desires the services of an engineer who is thoroughly familiar with the cost of truck fleet operation and the unit cost of door-to-door delivery. Location, New York City.

207 BODY DESIGNER AND DRAFTSMAN Man to grow up in the business, preferably just out of college, is wanted. Experience not necessary. Location, suburb of New York City.

See announcement at the head of the "Positions and Men Available" column, page 44.


THE high carbon chrome alloy steel of which New Departure Ball Bearings are made is fundamental of New Departure guaranteed QUALITY.
THE NEW DEPARTURE MFG. CO.
Detroit Bristol, Conn. Chicago
New Departure
Ball Bearings

SOURCES OF SUPPLIES

An Index to Advertisers' Products Marketed as Conforming With S.A.E. Standards and Recommended Practices and to Products for Which There Are No S.A.E. Standards

Absorbers, Shock
Houdaille Co.
Watson Co., John Warren

Accelerator Heel Rests
Auto Pedal Pad Co.

Adjusters, Brake-Rod
Ford Mfg. Co., M. J.

Alloys, Steel (See Steels)

Ammeters, B12
*Nagel Electric Co., W. G.
Westinghouse Electric & Mfg. Co.

Apparatus, Laboratory
Olsen Testing Machine Co., Tinius

Apparatus, Charging, Electric Vehicle
Westinghouse Electric & Mfg. Co.

Babbitt, D49
*Light Mfg. & Foundry Co.
*Muzzy-Lyon Co.

Balls, Composition, Control Lever, J2
American Insulator Corporation

Bars, Boring
Williams & Co., J. H.

Bars, Bronze Cored
American Bronze Corporation

Batteries, Storage, B23
*Marko & Co., Inc., Paul M.
*Willard Storage Battery Co.

Bearing Metal, Bronze
American Bronze Corporation

Bearings, Babbitt and Aluminum
Doehler Die-Casting Co.

Bearings, Bronze
Muzzy-Lyon Co.

Bearings, Babbitt and Bronze
Doehler Die-Casting Co.
Muzzy-Lyon Co.

Bearings, Ball, Angular Contact Type, C33 to C33c
*Bearings Co. of America
*Fafnir Bearing Co.
Gurney Ball Bearing Co.
*New Departure Mfg. Co.
*U. S. Ball Bearing Mfg. Co.
*S. K. F. Industries, Inc.

Bearings, Ball Annular, Extra Small Series, C33
*Fafnir Bearing Co.
*New Departure Mfg. Co.
*S. K. F. Industries, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Annular, Extra Large, Light and Medium Series, C27 and C29
*Fafnir Bearing Co.
Gurney Ball Bearing Co.
*S. K. F. Industries, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Annular, Light, Medium and Heavy Series, C26, C28 and C30
*Fafnir Bearing Co.
*Federal Bearings Co., Inc.
Gurney Ball Bearing Co.
*New Departure Mfg. Co.
*Norma Co. of America
*S. K. F. Industries, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Annular, Separable (Open) Type, C32
*Fafnir Bearing Co.
*New Departure Mfg. Co.
*Norma Co. of America
*S. K. F. Industries, Inc.

Bearings, Ball, Annular, Wide Type, C31
*Brown-Lipe Gear Co.
*Fafnir Bearing Co.
*New Departure Mfg. Co.
*S. K. F. Industries, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Thrust, Ball, Clutch Release Type, C39
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Single-Direction, Flat-Face Type, C35 and C36
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Single-Direction, Self-Aligning Type, C37 and C38
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Steering Knuckle Type, C34
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*U. S. Ball Bearing Mfg. Co.

Bearings, Bronze
American Bronze Corporation

Bearings, Roller, C43 and C44
Bower Roller Bearing Co.
Gilliam Mfg. Co.
Hyatt Roller Bearing Co.
*Norma Co. of America
Timken Roller Bearing Co.

Blanks, Gear
Canton Drop Forging & Mfg. Co.
Central Steel Co.
Link-Belt Co.
Park Drop Forge Co.

Bodies, Passenger Car
Baker R & L Co.

Bodies, Motor Truck Dump
Mansfield Steel Corporation

Bolts, Hexagon Head C2
*Steel Products Co.

Bolts, Connecting-Rod, A5
*Steel Products Co.

Bolts, Eye
Williams & Co., J. H.

Bolts, Spring Shackle
Bowen Products Corporation

Brackets, Fender
Parish & Bingham Corporation
Parish Mfg. Corporation
Smith Corporation, A. O.

Brackets, Running-Board
Crosby Co.
Parish & Bingham Corporation
Parish Mfg. Corporation
Sharon Pressed Steel Co.
Smith Corporation, A. O.

Brake-Drums
Crosby Co.
Parish & Bingham Corporation
Parish Mfg. Corporation
Sharon Pressed Steel Co.
Smith Corporation, A. O.

Brake-Rod Assemblies
Ford Mfg. Co., M. J.

Brakes
Raybestos Co.

Brass, Laminated
Laminated Shim Co., Inc.

Bulbs, Incandescent Lamp, B3
Westinghouse Electric & Mfg. Co.

Bumpers, Motor Truck
Mansfield Steel Corporation

Bumpers, Spring
Thermoid Rubber Co.

Bushings, Babbitt
Muzzy-Lyon Co.

Bushings, Bronze
American Bronze Corporation
Muzzy-Lyon Co.

Cable, Insulated, B33
Kerite Insulated Wire & Cable Co.
*Rome Wire Co.

Cable, Starting Motor, B21
*Rome Wire Co.

Camshafts
Canton Drop Forging & Mfg. Co.
Muskegon Motor Specialties Co.
Park Drop Forge Co.
Wyman-Gordon Co.

Caps, Hub
Crosby Co.

Caps, Radiator and Tank, C58
American Insulator Corporation

Carbureters, A8
Penberthy Injector Co.

Castings, Aluminum**
American Bronze Corporation
*Doehler Die-Casting Co.
*Light Mfg. & Foundry Co.

Castings, Brass**
American Bronze Corporation
*Doehler Die-Casting Co.
*Light Mfg. & Foundry Co.
*Scovill Mfg. Co.

Castings, Bronze**
American Bronze Corporation
*Doehler Die-Casting Co.
*Light Mfg. & Foundry Co.

Castings, Die
Doehler Die-Casting Co.
*Light Mfg. & Foundry Co.
Soss Mfg. Co.

Castings, Grey Iron
Link-Belt Co.

Castings, Malleable Iron, D12
*American Malleable Castings Ass'n
Eberhard Mfg. Co.
*Link-Belt Co.

Castings, Steel
Link-Belt Co.

Chains, Block
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

Chains, Roller, E3
*Baldwin Chain & Mfg. Co.
*Link-Belt Co.
*Whitney Mfg. Co.

Chains, Silent, E2
*Link-Belt Co.
*Morse Chain Co.
Whitney Mfg. Co.

Chains, Tire, Motor-Truck
Arrow Grip Mfg. Co., Inc.

Clamps, Hose, C51
Schrader's Son, Inc., A.

Clamps, Machinists'
Eberhard Mfg. Co.
Williams, J. H., & Co.

(Continued on page 66)

EXPLANATION OF SYMBOLS

Parts and Materials followed by key numbers have been standardized by the S. A. E. The numbers refer to S. A. E. HANDBOOK data sheets on which each standard is published.

*Companies whose names are preceded by an asterisk supply the parts or materials under which the company is listed as conforming with the S. A. E. Standard referred to.

**Parts and Materials followed by two asterisks indicate that two or more S. A. E. Standards are applicable. Information as to standards incorporated should be obtained from the manufacturer.

The addresses of companies listed in Sources of Supplies can be obtained from their current advertisements indexed on page 70.

SOURCES OF SUPPLIES

Clutches, Engine, A1 and A2
*Brown-Lipe Gear Co.

Clutches, Power Transmission
Link-Belt Co.

Coils, Electrical Equipment
Acme Wire Co.

Conduit, Flexible, C52
*Titeflex Metal Hose Corporation

Connections, Tire-Pump
Schrader's Son, Inc., A.

Controls**
*Brown-Lipe Gear Co.

Cooling Systems**
*G & O Mfg. Co.
*Long Mfg. Co.
United States Cartridge Co.

Couplings, Flexible
Thermoid Rubber Co.

Covers, Axle-Housing
Sharon Pressed Steel Co.

Cranes, Portable Electric
Link-Belt Co.

Cranks, Starting, A15
*Steel Products Co.

Crankshafts
Canton Drop Forging & Mfg. Co.
Park Drop Forge Co.
Vibration Specialty Co.
Wyman-Gordon Co.

Cups, Oil and Grease, C57
*Bowen Products Corporation

Cutters, Milling
Haynes Stellite Co.

Cutters, Woodruff
Whitney Mfg. Co.

Dampers, Vibration
Vibration Specialty Co.

Dashes
Parish Mfg. Corporation

Distributors, Ignition, B16
*Atwater Kent Mfg. Co.
*North East Electric Co.

Drive, Starting Motor
Eclipse Machine Co.

Drop-Forgings
Canton Drop Forging & Mfg. Co.
General Drop Forge Co.
Park Drop Forge Co.
Williams & Co., J. H.
Wyman-Gordon Co.

Engines, Marine**
Wisconsin Motor Mfg. Co.

Engines, Motor Truck**
*Continental Motors Corporation
*Light Mfg. & Foundry Co.
Wisconsin Motor Mfg. Co.

Engines, Passenger Car**
*Continental Motors Corporation
*Light Mfg. & Foundry Co.
Wisconsin Motor Mfg. Co.

Engines, Tractor**
*Continental Motors Corporation
*Light Mfg. & Foundry Co.
Wisconsin Motor Mfg. Co.

Equipment, Foundry
Standard Pattern Works of Detroit, Inc.

Facings, Clutch
Johns-Manville, Inc.
Thermoid Rubber Co.
Raybestos Co.

Fans, Radiator
Sparks-Withington Co.

Fasteners, Hood
Eberhard Mfg. Co.

Felt
American Felt Co.

Felloe-Bands, Motor-Truck, Pneumatic Tire, G4
*Motor Wheel Corporation

Fenders
Parish Mfg. Corporation

Fibre, Vulcanized
American Vulcanized Fibre Co.

Flanges, Hub
Crosby Co.
Parish & Bingham Corporation
Smith Corporation, A. O.

Flow-Meters
Penberthy Injector Co.

Forgings, Brass
Scovill Mfg. Co.

Forgings, Drop (See Drop-Forgings)

Frames, Pressed Steel
Detroit Pressed Steel Co.
Parish & Bingham Corporation
Parish Mfg. Corporation
Sharon Pressed Steel Co.
Smith Corporation, A. O.

Frames, Rolled Section
Mansfield Steel Corporation

Fuel-Feed Systems
Sparks-Withington Co.

Fuses, Electric, B32
*Johns-Manville, Inc.

Gages, Gasoline
Penberthy Injector Co.
Nagel Electric Co., W. G.

Gages, Oil, B12
*Nagel Electric Co., W. G.

Gages, Tire Pressure
Schrader's Son, Inc., A.

Gasoline
Texas Co.

Gears, Bevel
Link-Belt Co.

Gears, Spur
Link-Belt Co.

Gears, Transmission
Canton Drop Forging & Mfg. Co.
Link-Belt Co.
Wyman-Gordon Co.

Gears, Worm
Link-Belt Co.

Generators, Battery Charging (Electric Vehicle)
Westinghouse Electric & Mfg. Co.

Generators (Bracket Mounting, B18)
*Atwater Kent Mfg. Co.
*North East Electric Co.
Westinghouse Electric & Mfg. Co.

Generators (Flange Mounting, B17)
*Atwater Kent Mfg. Co.
*North East Electric Co.
Westinghouse Electric & Mfg. Co.

Graphite
Dixon Crucible Co., Jos.

Greases, Cup and Gear
Dixon Crucible Co., Jos.
Texas Co.

Grease-Cups, C57
*Link-Belt Co.

Guards, Radiator
Mansfield Steel Corporation

Handles, Machine-Tool
Williams & Co., J. H.

Hardware, Body
Soss Mfg. Co.

Heaters, Passenger-Car Body
Perfection Heater & Mfg. Co.

Hinges, Door
Eberhard Mfg. Co.

Hinges, Windshield
Eberhard Mfg. Co.

Hitches, Trailer, K42
*Mansfield Steel Corporation

Hoists, Power and Hand
Mansfield Steel Corporation

Holders, Tool
Williams & Co., J. H.

Hooks, Towing
Mansfield Steel Corporation

Horns, Hand
E. A. Laboratories, Inc.

Horns, Motor-Driven
E. A. Laboratories, Inc.
North East Electric Co.
Sparks-Withington Co.

Hose, Gasoline
Thermoid Rubber Co.

Hose, Radiator, C51
*Thermoid Rubber Co.

Housings, Axle
Crosby Co.
Parish & Bingham Corporation
Parish Mfg. Corporation
Sharon Pressed Steel Co.
Smith Corporation, A. O.

Hubs, Wheel
Smith Corporation, A. O.

Ignition-Generators
North East Electric Co.

Instruments, Vibration, Indicating and Recording
Vibration Specialty Co.

Insulation, Molded
American Insulator Corporation
General Bakelite Co.

Jacks, Wheel
Arrow Grip Mfg. Co., Inc.

Jars, Storage Battery, B39
*Marko & Co., Inc., Paul M.

Keys, Woodruff
Whitney Mfg. Co.

Keys, Spring
Williams & Co., J. H.

Levers, Brake
Ford Mfg. Co., M. J.

Lining, Brake, C55
*Johns-Manville, Inc.
*Raybestos Co.
*Thermoid Rubber Co.

Locks, Automobile
Karlok Mfg. Co.

Lubricants, D65
Dixon Crucible Co., Jos.
Texas Co.

Lubricating Systems
Bowen Products Corporation

Machines, Balancing
Olsen Testing Machine Co., Tinius
Vibration Specialty Co.

Machines, Power Transmission
Link-Belt Co.

Machines, Testing
Olsen Testing Machine Co., Tinius

Magnetos, B14
*Scintilla Magneto Co., Inc.
*Teagle Co.

Molybdenum, Metallic
Vanadium Corporation of America

Motors, Electric Vehicle
Westinghouse Electric & Mfg. Co.

Motors (See Engines)

Motors, Starting (See Starting Motors)

Mufflers, Carbureter
Maxim Silencer Co.

Mufflers, Engine
Maxim Silencer Co.

Mufflers, Heater
Maxim Silencer Co.

Nails
Interstate Iron & Steel Co.

Nuts, Thumb
Williams & Co., J. H.

Odometers, Hub, F2
*Johns-Manville Co., Inc.

Oil-Pans, Engine
Sharon Pressed Steel Co.

Oils (See Lubricants)

Packing, Asbestos and Fibrous
Johns-Manville, Inc.

Pads, Pedal
Auto Pedal Pad Co.

Pads, Accelerator
Auto Pedal Pad Co.

Paints
Dixon Crucible Co., Jos.

Parts, Pressed Steel (See Stampings)

Patterns, Wood and Metal
Standard Pattern Works of Detroit, Inc.

Pedals, Extension
Auto Pedal Pad Co.

Pencils, Drawing
American Lead Pencil Co.
Dixon Crucible Co., Jos.

Pins, Cotter, C7
*Ford Mfg. Co., M. J.
*Williams & Co., J. H.

Pins, Rod-End, C10
*Ford Mfg. Co., M. J.
*Steel Products Co.

Piston-Rings (for Standard Piston-Ring Grooves, A6)
*Ever-Tyte Piston Ring Division

Power Take-Offs, E1
Brown-Lipe Gear Co.

Primers, Engine
Master Primer Co.

Products, Screw-Machine
Link-Belt Co.
Rich Tool Co.
Scovill Mfg. Co.

Radiators**
*G & O Mfg. Co.
*Long Mfg. Co.
Sparks-Withington Co.
United States Cartridge Co.

Re-Vaporizers, Gasoline
Penberthy Injector Co.

Rectifiers, Battery Charging
Westinghouse Electric & Mfg. Co.

Relays, Cut-Out
North East Electric Co.

Retainers, Ball
Bearings Co. of America

Rims, Pneumatic Tire, G1
*Motor Wheel Corporation

Rivets, Steel
Interstate Iron & Steel Co.

Rivets, Brass and Copper
Rome Brass & Copper Co.
Scovill Mfg. Co.

Rod-Ends, C8
Eberhard Mfg. Co.
*Ford Mfg. Co., M. J.
*Steel Products Co.

Rods, Brass, C57b and D57c
*Rome Brass & Copper Co.
*Scovill Mfg. Co.

Rods, Bronze and Copper
Rome Brass & Copper Co.

Rods, Fibre
American Vulcanized Fibre Co.

Roller Bearings (See Bearings, Roller)

Running-Boards
Parish & Bingham Corporation
Parish Mfg. Corporation
Sharon Pressed Steel Co.
Smith Corporation, A. O.

(Concluded on page 68)

The Index to Advertisers is given on page 70

SOURCES OF SUPPLIES

The Index to Advertisers is given on page 70

INDEX TO ADVERTISERS

An index to advertisers' products is given on pages 64, 66 and 68


CARRIES THE LOAD
TAKES THE THRUST
BOWER Roller Bearings in a Car speaks volumes for the engineering care that particular car is favored with.
BOWER ROLLER BEARING CO. Detroit Michigan
Exclusive Bower Features
Separate bearing surfaces for load and thrust. Parallel raceways. Self-aligning. Never need adjusting. Does not develop end thrust under loads. Will not bind or end-slip.
BOWER SAVES POWER

STANDARDIZATION
NUMBER